Methodology for Achieving GASB 34 Modified Approach Compliance Using U.S. Navy "Smart Base" Facility Management Practices

by

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Abstract

Historically, local infrastructure assets have been overlooked and under-funded, viewed more often as sunk costs than as strategic assets. While the growth of enterprise software solutions for asset management has begun to change this, the high cost and complexity of such systems has primarily limited their implementation to large government agencies and major cities. With the creation of its Statement 34 requirements, the Government Accounting Standards Board (GASB) seeks to improve the tracking, management and reporting of infrastructure assets by smaller cities and towns. Due to phase in between 2001 and 2003, depending on annual revenue levels, GASB 34 has forced a renewed focus on infrastructure portfolios at the local level.

This research develops a strategy and methodology for small local governments to create flexible, cost effective asset management systems. Faced with the management of a global infrastructure portfolio exceeding $130 billion in 2001, the U.S. Navy has invested heavily in the area of public works management. The Smart Base project at Naval Shipyard Portsmouth, an ongoing initiative to develop customized information technology solutions at the installation level, is examined as a model for small towns to emulate during the development of GASB 34 compliant asset management systems. The resultant methodology provides a simple, robust framework for the integration of inventory, condition and valuation data within the existing GIS system used by the town of Winchester, Massachusetts.

Thesis Supervisor: John B. Miller
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I am indebted to the public works staff at Naval Shipyard Portsmouth, especially CAPT Duffy, LT Hiser and John Wyeth. Their willingness to discuss the developmental dead ends, in addition to the final successes, was critical to understanding the full impact of the Smart Base initiative. Their vision and pioneering spirit was an inspiration.

My gratitude extends to the U.S. Navy and the Civil Engineer Corp. My seven years have provided a world of experiences and opportunities beyond my wildest expectations. Their willingness to invest in education and training of personnel reflects a sense of dedication and vision that is second to none.

Biographic Note

Michael D. Crafts is a Lieutenant in the United States Navy Civil Engineer Corp. A native of Lisbon Falls, Maine, he received his Bachelor of Science Degree in Mechanical Engineering from the University of Maine at Orono and Master in Business Administration from New Hampshire College. Lieutenant Crafts was commissioned through Officer Candidate School in 1996.

His first duty station was at Naval Station Roosevelt Roads in Ceiba, Puerto Rico. Serving as an Assistant Resident Officer in Charge of Construction, he performed contract management on construction projects throughout Puerto Rico, Vieques and the U. S. Virgin Islands. While managing over 30 construction projects exceeding $25 million, he developed expertise in such diverse areas as landfill construction, barracks renovation, airfield utilities, pier upgrades, fuel tank fabrication and hurricane recovery efforts.

Lieutenant Crafts was then reassigned to U. S. Naval Mobile Construction Battalion SEVENTY-FOUR in Gulfport, Mississippi. While deployed to Okinawa, Japan, he served as the Material Liaison Officer, Communications Officer, CMS Custodian, Public Affairs Officer, and Headquarters Company Commander. Later, as the Officer in Charge of Detail Guantanamo Bay, Cuba, he led 35 Seabees in support of construction, blasting and quarrying operations.

Lieutenant Crafts' decorations include the Navy and Marine Corps Achievement Medal, Navy Meritorious Unit Commendation Ribbon, Battle "E" Ribbon, National Defense Service Medal, and Humanitarian Service Medal. He is a qualified Seabee Combat Warfare Specialist.

Chapter 1 Introduction

1.1 Background

Historically, local infrastructure systems have been overlooked and under funded. Heavy reliance on construction and maintenance funds provided by the federal and state governments has created a harmful short-term focus by local infrastructure managers. The unpredictability of these funding sources, driven by both political and economic pressures outside of local control, severely restricts the effective planning horizon. In addition, significant funding subsidies are applied primarily to construction projects, undermining more cost effective mean of maintaining and extending the life-cycle of existing infrastructure assets.

The end result is that most small towns and cities demonstrate little or no systematic use of infrastructure management processes. Information on current asset condition is extremely limited, infrequently updated, scattered among various data types and rarely integrated. Useful performance benchmarks can not be established, as the underlying financial and repair tracking data is inadequate to support the development of timely, detailed analysis. Funds are allocated based on current appropriations received and the level of previous expenditures, rather than the analysis of the true short and long-term infrastructure needs. Increased funding pressures, combined with revised accounting standards for local governments, have emerged as a driving force towards more effecting infrastructure management practices at the local level

1.2 Focus Areas

Three principle focus areas will be covered in this thesis. First, the new accounting and asset reporting standard required by the Government Accounting Standards Board (GASB) Statement 34 will be examined and discussed. Particular emphasis will be placed on the differences between available compliance methodologies and their potential short and long-term impacts and benefits to infrastructure management practices. Second, past and current U.S. Navy practices and initiatives regarding the use of

information technology (IT) for public works operations and portfolio management will be examined. Finally, recommendations will be presented for the development and implementation of low-cost IT strategies for complying with the GASB 34 modified approach.

1.3 Hypothesis

The creation of an effective, low-cost strategy for implementing basic asset management systems at the local level is critical for the full impact and benefit of GASB 34 to be realized. Instead of investing significant resources on the purchase of elaborate commercial hardware and software packages or the painful development of proprietary solutions, local governments can benefit from an examination of the groundwork and experiences of larger governmental infrastructure managers. The hypothesis of this research is:

> *The implementation and adaptation of existing U.S. Navy asset management experience and practices can minimize both the expense and difficulty of local governments implementing the modified approach to GASB Statement 34 compliance.*

1.4 Research Approach

Case study methodology, in combination with a thorough literature review, was used to examine the feasibility of transferring infrastructure management knowledge and experience between Naval bases and small towns. Naval Shipyard Portsmouth, located in Kittery, Maine, was selected due to recent experiences developing and implementing innovative infrastructure management tools under the Smart Base initiative. Topics covered include: Naval Facilities Engineering Command (BNAVFAC) infrastructure management practices, local base public works department procedures, past and present IT strategies, and the experiences and lessons learned from the first two phases of the Smart Base project. The town of Winchester, Massachusetts provides the second case, with emphasis placed on developing a functional framework for expanding an existing Graphical Information System (GIS) into a GASB 34 compliant asset management system.

Chapter 2 Choosing a GASB 34 Reporting Approach

2.1 Background

For the past several decades, infrastructure maintenance has often been overlooked at the state and local levels. During the 1950s and 1960s, the federal Highway Trust Fund restricted the use of provided funds to new construction, forcing state and local governments to use their own revenues for maintenance.[1] These policy decisions created several unintended impacts that have led to the infrastructure O&M issues faced by local governments today. Cash strapped local governments began a habit of earmarking their limited dollars to match federal funds for new projects, leading them to defer maintenance on existing infrastructure. Additionally, the post-WWII construction boom created a large increase in the infrastructure portfolios of many towns, increasing future O&M requirements. Although the easing of these restrictions in later decades brought greater funding for rehabilitation and restoration, O&M spending has not kept pace with the needs of these rapidly aging portfolios. Even as the bulk of local infrastructure began exceeding fifty years of age, in 2000 all levels of government still spent almost twice as much on capital projects as on O&M.[1] The end result is rapidly aging infrastructure, deteriorating conditions and a growing backlog of deferred O&M requirements.

In June 1999, the Government Accounting Standards Board (GASB) issued Statement No. 34. Intended to adapt and apply private-sector financial reporting requirements to the public-sector, GASB 34 outlines new governmental accounting rules. Most important from an infrastructure standpoint, GASB 34 mandates the use of full accrual accounting methods that will drive the inclusion of long-lived capital assets in government financial statements.

2.2 Purpose of GASB 34

"Statement 34 establishes methods for governments to be more accountable to bond market analysts and underwriters, citizens, and other financial users."[2] GASB aims to derive better information about:

- Operating results
- Government financial positions
- How and when government service expenses are incurred, and
- How governments compare to each other.

This is to be accomplished through increased transparency and consistency of reporting.

As one of the largest classes of assets and source of annual expenses for local governments, the reporting of infrastructure financial detail is a primary focus of Statement 34. Historical accounting and budgeting practices have been proven unable to adequately support the management of infrastructure at a local level. An over reliance on federal and state funding sources, combined with a short-term fiscal year driven focus, has inhibited the implementation of capital asset management practices in local governments. Inadequate O&M funds must often be diverted from scheduled maintenance to solve emergent problems. This "worst first" allocation method is complaint driven, marginalizes attempts at long-term planning, and focuses on patchwork solutions at the expense of the overall portfolio condition.

Transparency:

Under current reporting requirements, accounting records are often inadequate to provide citizens and investors with a clear picture of local government performance. Summary accounts of expenses related to infrastructure spending provide little guidance as to how and where financial resources are allocated. The lack of condition assessments adds to the problem by making the success of infrastructure investment impossible to document and analyze.

Reporting Consistency:

In order to aid the analysis and direct comparison of government finances, GASB 34 sets minimum requirements for the statements to be included in annual financial reporting. Administratively, a Management Discussion and Analysis (MD&A) section must provide a non-technical overview of the past years performance, including comparisons with prior years. Government-wide financial statements must include a Statement of Net Assets and Statement of Activities. Fund financial statements will now be required to report separately on various categories of funds, including governmental funds, proprietary funds and fiduciary funds.

2.3 Implementation Timeline

The required dates for implementation of the GASB 34 requirements are related to the size of local governments, as represented by their total annual revenues. The three tiers are summarized in the table below[2]: In addition, the reporting for each tier is split into two portions, prospective and retroactive. Initially, governments will only need to report on new infrastructure assets by the prospective deadline. Four years later, all Phase I and II governments will have to perform retroactive reporting on all assets built or improved after June 15, 1980.

Local Government Type	Annual Revenues (Millions of $)	Prospective Deadline	Retroactive Deadline
Phase I	> 100	June 15, 2001	June 15, 2005
Phase II	10 - 100	June 15, 2002	June 15, 2006
Phase III	< 10	June 15, 2003	Optional

Table 2.1: Statement 34 Implementation Deadlines

2.4 Standard vs. Modified Approach

Prior to the issuance of Statement 34 in June 1999, the GASB spent 12 years gathering input and revising the requirements, beginning with the publication of Statement 1 in 1987. The sections of GASB 34 pertaining to public infrastructure make up only a portion of the overall guidelines, yet they became the focus of a large amount of public

input and months of discussion. The basic approach in most government and private accounting involves the practice of depreciating assets, either over their expected useful life or in accordance with IRS regulations. The initial GASB concepts revolved around this format, as demonstrated by the requirement to report retrospectively for assets less than 20 years old. However, public infrastructure management agencies, particularly state agencies tasked with the construction, maintenance and preservation of roads, argued that a depreciation approach would not accurately represent the performance of their infrastructure portfolios.

In response, the GASB established a special task force comprised of infrastructure experts from the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHA). These agencies concluded that attempts to maintain transportation assets at a constant condition level indefinitely make it difficult to estimate the number of years constituting useful life.[2] The result was the creation of a set of alternative reporting requirements in GASB Statement 34, which are commonly referred to as the Modified Approach.

Both methods, Standard and Modified, split infrastructure costs for each asset into three categories: maintenance, preservation, and additions and improvements. Maintenance includes routine repairs to maintain usability, such as filling potholes. Preservation includes work that seeks to extend the life of the infrastructure, such as seal coating a road. Additions and improvements increase the size of an asset, such as extending a paved road into a new subdivision or widening a highway. All three must be tracked separately regardless of the method chosen, but are accounted for differently as summarized in the table below:

	Allocation of Costs	
Cost Type	Standard	Modified
Maintenance	Expense	Expense
Preservation	Capitalize	Expense
Additions / Improvements	Capitalize	Capitalize

Table 2.2: Cost Allocation Matrix

2.4.1 Standard Approach

Under the standard approach, GASB 34 requires local governments to depreciate infrastructure assets using generally accepted accounting principles (GAAP). This is to be accomplished by allocating the net cost of the infrastructure over its useful life. The net cost is calculated as the historical cost of the infrastructure asset minus the salvage value. The selection of useful life is more subjective, as the current condition must be used to estimate how long it can continue to support service demands. Under this approach, expenditures for preservation and improvements must be capitalized and added to the asset value, requiring adjustment of both the useful life estimate and the depreciation schedule. Maintenance costs continue to be recorded as an expense and do not affect the depreciation of the asset.

2.4.2 Modified Approach

The modified approach, favored by the AASHTO, allows local governments to value infrastructure by reporting on the costs and consequences of preserving it.[1] As will be discussed in greater depth in the following chapters, this approach is based on the concept of asset management and supports the viewpoint that infrastructure which is adequately maintained can have its useful life continually expanded and therefore does not warrant depreciation. Under this option, only additions and improvements are capitalized, while both maintenance and preservation costs are reported as expenses.

2.5 Mission of the GASB

"The mission of the Governmental Accounting Standards Board is to establish and improve standards of state and local governmental accounting and financial reporting that will result in useful information for users of financial reports and guide and educate the public, including issuers, auditors, and users of those financial reports."[3]

Local governments will be required to invest time and money to achieve GASB 34 compliance. More importantly, these new requirements will force governments to reconsider the way they view and manage their infrastructure portfolios. For the first

time, infrastructure will be viewed not as a sunk cost or unwanted source of expense, but rather as a group of assets.

In selecting between the Standard and Modified reporting methods, both potential objective and subjective impacts need to be considered. Areas such as existing accounting systems, levels of pre-existing data integration, and past management viewpoints will all come into play to varying degrees. The danger is that many smaller towns and cities will focus heavily on the up-front costs involved with implementing each approach, rather than consider the long-term impact and benefits of each method. As previously discussed, one of the primary goals of the GASB is to bring the same kind of financial accountability to local governments that the FASB brings to private companies.

There is no doubt that local governments will comply with GASB 34, as refusing to do so would be too damaging to their credibility with the financial services industry. By one measure, the successful implementation of consistent reporting standards will make Statement 34 a success. But the true measure of the long-term impact will be the extent to which local governments go beyond the minimum, seizing the opportunity to improve their practices and outlook. Local governments must learn to think like private companies, deciding to invest capital based on the principles of maximizing long-term value rather than simply minimizing short-term costs. The choice between reporting methods is exactly this type of management decision.

2.6 Differences in Requirements for Implementation

In a very basic sense, the standard and modified approaches view infrastructure assets from almost completely opposite perspectives. The standard approach seeks to value infrastructure as function of age, regardless of condition. Conversely, the modified approach seeks to establish value as a function of condition, regardless of age. Interestingly, the implementation requirements are also at opposite ends of the spectrum, with the standard approach dependent on accounting tools and the modified approach on asset management tools.

2.6.1 The Standard / Depreciation Approach

At its core, the standard approach is almost exclusively an accounting issue, and therefore easier to adapt into current practices. Depreciation is a long-established, well-documented practice that is easily incorporated into standard accounting systems. The most difficult part of the standard approach is the fact that maintenance and preservation expenditures must be separately documented and applied differently, the former recorded as expenses and the latter capitalized. This may prove difficult to incorporate into existing public works accounting procedures, which are commonly structured to record expenses based on categories such as labor or materials, rather than by project or type of work. Additionally, fully depreciated assets will need to be added to the depreciation database whenever preservation work is performed on them, causing the reported list of infrastructure assets to vary between fiscal years.

2.6.2 The Modified Approach

As previously discussed, the modified approach was not originally a part of the GASB reporting initiative. Championed by the AASHTO and state DOTs, it was created specifically to deal with the special scenarios posed by infrastructure assets. Because of the immense difficulty in replacing major highways and bridges, these large agencies utilize sophisticated asset management systems that seek to maintain and preserve these infrastructure assets indefinitely. As a result, the modified approach is built around the reporting of information analogous to their management systems.

In order to utilize the modified approach, the GASB has set minimum criteria for asset management system capabilities. Statement 34 requires that governments utilizing the modified approach must be able to:

- Have a current inventory of eligible assets
- Document the condition of those assets via a reproducible assessment procedure.
- Demonstrate that assets are being preserved at a predetermined level
- Estimate the actual cost to maintain and preserve the assets[2]

2.6.3 Summary of Requirements

	Complete Asset Database	Condition Assessments	Demonstrate Adequate Preservation	Calculate Future Preservation Costs / Needs	Annual Performance Comparisons	Separate Tracking of Maint. & Preservation
Standard	NO	NO	NO	NO	NO	YES
Modified	YES	YES	YES	YES	YES	NO

Table 2.3: Comparison of Reporting Requirements

2.7 Why Is Asset Management So Important?

The implementation of asset management systems should drive the shift to a long-term, big-picture view of infrastructure portfolios. For the past 50 years, local governments have been caught in a vicious, short-sighted infrastructure policy battle. New projects are heavily subsidized by federal and state funds, with only token local investments required. Maintenance, which relies heavily on the allocation on local funding, is often postponed and neglected. The resultant premature infrastructure failure creates the need for emergency replacement projects, which allows the town to again rely on state and federal subsidies. This attitude of treating infrastructure as a sunk cost and maintenance as an undesirable expense has resulted in the creation of dysfunctional portfolios of assets at the local level.

2.7.1 Lower Life-Cycle Costs

Asset management seeks to provide a process and framework for implementing cost-effective resource allocation. These systems focus on preserving infrastructure assets and minimizing life-cycle costs by taking better care of them. Just as preventative medicine is less expensive than emergency room visits, adequate investments in maintenance and upgrades is more cost effective than total reconstruction projects. "Asset management encourages infrastructure managers to consider trade-offs between deferred maintenance

and preservation, between short-term fixes and long-term solutions, and between today's costs and tomorrow's benefits."[1]

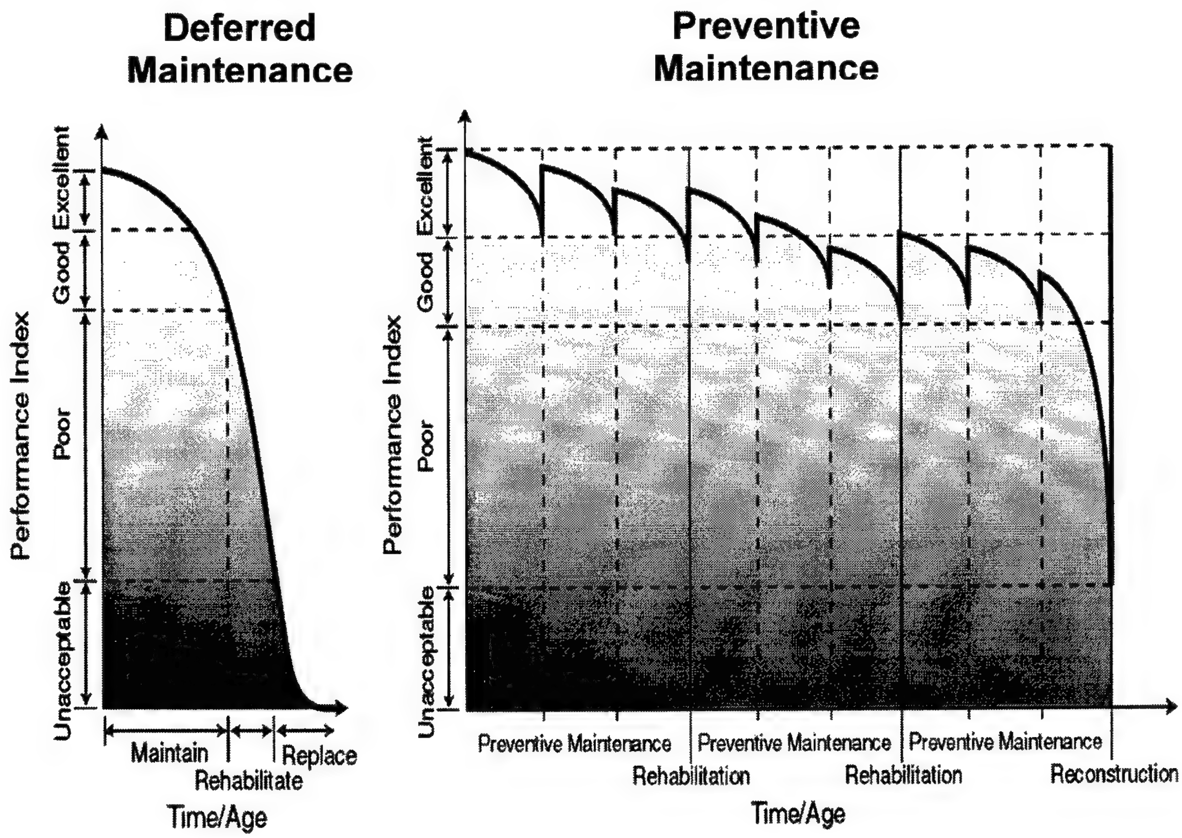


Figure 2.1: Effects of Maintenance and Rehabilitation on Asset Life[1]

2.7.2 Quality of Information Provided

One significant drawback of the standard approach is that it does not provide a full picture of the infrastructure portfolio, rendering the GASB 34 data useless as a planning tool. For example, unimproved infrastructure assets built before June 15, 1980 are not recorded, even after the implementation of full retroactive reporting. No retroactive asset reporting is required for towns with annual revenues less than $10 million. Additionally, the use of depreciated asset values prevents the calculation of ratios and percentages that can be used to benchmark public works performance across towns, regions and states. In comparison, the use of asset management practices under the modified approach can provide a wide variety of useful planning and performance data.

Asset Condition:

The GASB 34 requirement to document the condition of the complete infrastructure portfolio under the modified approach provides a useful source of data. It will present local government officials with a big-picture view of town assets, supporting a strategic assessment of future needs. Even more useful is the requirement to regularly reassess the portfolio condition and document its progress over time, providing an objective direct measure of whether adequate maintenance funds are being allocated.

Accurate Cost Data:

Public works maintenance and construction budgets are often based on the value of the previous year allocations, rather than an independent assessment of actual department needs. Just as the need to maintain condition levels will place a spotlight on PW funding, so will the ability to easily document preservation and replacement costs. Under the modified approach, the asset management systems used must be able to estimate the annual amount required to maintain and preserve the portfolio at pre-established condition levels. The availability of calculations for rehabilitation and replacement options can provide valuable guidance for strategic planning and allocation decisions.

Benchmarking Ratios:

A clear advantage of GASB 34 is that by having standard infrastructure reporting requirements, local governments will be able to directly compare their level of performance. To develop ratios and percentages for desired criteria, complete and comparable portfolio information is required.

For example, real property maintenance spending is often expressed as a percentage of current plant value.[4] The Navy has estimated that the real property maintenance funding required is 2.1% of replacement value[5], and uses this calculation as a quick indicator of the adequacy of yearly appropriations. However, this calculation requires on the value of the total infrastructure portfolio, which is only provided under the modified approach. Creation of other ratios, such as the percentage of assets in certain conditions codes, is also dependent on the presence of complete asset information.

2.8 Summary

A governments choice of GASB 34 compliance method is a critical decision with long-term consequences. Although the standard method is likely to be easier and less expensive to implement initially, the value of the information provided is severely limited and will do little to change the way infrastructure is financed, documented, and managed. While initially more challenging and expensive to implement, the asset management requirement of the modified approach provides far greater levels of long-term value through the development of valuable data. While both standard and modified methods can be used simultaneously for different asset classes within an infrastructure portfolio, the added complexity of maintaining two systems is not recommended.

Local governments where the leadership is predisposed towards striving to meet only the minimum standards will clearly choose the standard approach, and continue to suffer with the negative effects of the same dysfunctional, short-sighted infrastructure policy currently in place. However, leadership that values the need for improvement will likely choose the modified approach, seeking the benefits of valuable data and strategic management capabilities. It is these governments that will be able to break the vicious infrastructure cycle and experience the future benefits envisioned by GASB.

Chapter 3 Challenges of Asset Management & the Modified Approach

3.1 Early Implementation Trends

With GASB 34 prospective reporting already in place for Phase I government entities with over $100 million in annual revenues, it is possible to begin to quantify the degree of modified approach adoption. In a 2001 survey of state infrastructure agencies, it was found that only 45% of replying states reported using the modified approach in pursuit of GASB 34 compliance.[6] Although only based on the responses of 29 states, the maximum possible adoption rate could not exceed 70%, even if all of the remaining states chose to use the modified approach. While this is not as high an adoption rate as predicted by the AASHTO, it is foreseeable that the rate may increase over the next few years in advance of the implementation of retroactive reporting in 2005.

Of some concern is that only 2 of 47 Phase II cities choosing to implement GASB 34 a year early have elected the modified approach, an adoption rate of less than 5%.[7] While this number may be skewed by the small data sample and the possibility that early adopters are more likely to choose simpler implementation methods, it provides an indication that smaller government entities perceive substantial difficulties in adopting the modified approach. Since the use of modified reporting is the key to GASB 34 creating a revolution in the way public infrastructure is managed, an examination must be made of the challenges and choices faced by these Phase II governments.

3.2 Sources of Resistance

Ironically, the very thing that makes the GASB 34 modified approach valuable may also be the greatest hindrance to its widespread implementation. The requirement to develop and implement an asset management system, while important to reversing a half-century of neglect in the operation and maintenance of public infrastructure assets, is a source of major resistance. Inexperience with the implementation and use of these types of systems in small towns creates a significant roadblock to their adoption. The U.S. DOT has

determined that the process can be extremely challenging for organizations with a history of stand-alone files and rarely sharing data across databases[8], and has published initial guidance on the subject of data integration. These recommendations are meant to reduce the fear and uncertainty surrounding the development of asset management systems.

Concerns over cost are also a major issue for small local governments. The standard approach to GASB 34 compliance is not only simpler to understand and implement, it is also the least expensive option available. Despite strong evidence showing the long-term cost benefits of asset management systems, the necessary up-front investments of time and money is an unpopular proposition for small local governments.

If the goal is to extend the use of the modified approach beyond just large state agencies, industry practices and alternatives will need to be examined to create an implementation framework for smaller users. Recommended asset management strategies must be straightforward, inexpensive and easy to use. To accomplish this, special emphasis needs to be placed on providing only the depth of capability desired by these small users, thereby eliminating unnecessary complexity, computing requirements and cost.

3.3 Determining Asset Management Objectives

"Data integration is the process of combining or linking two or more data sets from different sources to facilitate data sharing, promote effective data gathering and analysis, and support overall information management activities in an organization."[8]

Asset management is a process and framework intended to utilize and analyze infrastructure data to make better short and long-term programming and allocation decisions. It does not, by definition, have to be an all-inclusive, fully-automated system. While state and federal agencies may be able to justify the difficulty and expense of implementing large, sophisticated IT hardware and software solutions, this is not the only option. Users with more manageable infrastructure portfolios, such as small towns and public universities, can simplify asset management implementation by working to

automate data collection and integration, while continuing to perform the planning and budgeting functions manually.

As shown by Figure 3.1, the asset management process can be viewed as a flowchart with multiple feedback loops. The framework is multi-disciplinary, including: policy development, asset inventory, budgeting, programming, and performance monitoring. While the entire process can be completed with a series of stand-alone databases and manually generated reports, ease of use and accuracy would be too low even for simple infrastructure portfolios. At a minimum, implementation should involve the integration of the foundation data in steps 2 and 3: asset inventory and condition assessment. At the other extreme, companies such as MRO Software, Inc. advocate the use of products and services allowing the use of a single enterprise management solution across organizations, integrating even such diverse public works function as supply chain and personnel management into a single system.[9]

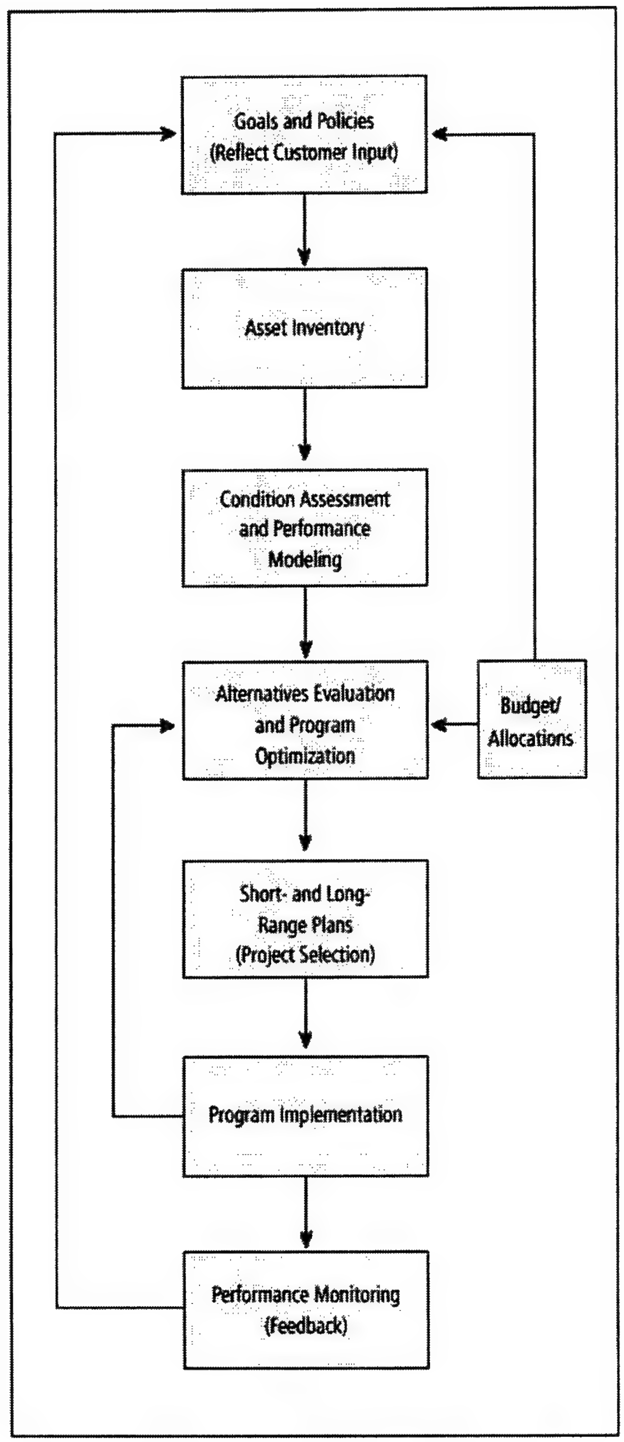


Figure 3.1 Asset Management Framework [8]

It is imperative that local governments invest the necessary time and effort to evaluate their needs, priorities and capabilities before selecting an asset management strategy. The U.S. DOT recommends the creation of a data integration team consisting of key stakeholders in the process, including: database users, asset managers, decision makers, budget managers and IT personnel. While outside consultants and developers may be needed at later stages, an educated customer must first determine internally the desired goals and types of outputs desired. Failure to do this initial planning will almost guarantee the development of a larger, more complex, higher cost system than required. For the purpose of this report, it will be assumed that the customer is a small local government which initially desires only to meet the minimum compliance requirements of the GASB 34 modified approach, while reserving the flexibility to easily include additional asset management functions in the future.

3.4 General Software Strategies

Perhaps the greatest impact on the overall life-cycle costs of implementing an asset management system is the selection between competing software strategies. Broken down into three basic architectures, they comprise a wide range of capabilities, flexibility, customer support, customization potential, hardware demands, ease of implementation and cost. Each strategy exhibits its own strengths and weaknesses, which must be evaluated in the context of a user requirements, pre-existing data capabilities and availability of resources for implementation and support.

3.4.1 Proprietary & Legacy Systems

Due to their status as some of the largest infrastructure portfolio managers in the world, state and federal agencies became early advocates and adopters of information technology. Lacking off-the-shelf commercial software solutions, these agencies funded the development of proprietary database and public works management tools, often using a wide variety of hardware platforms and software technologies. After decades of IT advancements, many of these independent legacy systems are still in use and based on obsolete standards, making maintenance and integration of data difficult.

While the challenges posed by legacy systems are formidable for these large agencies, they are generally not applicable to local governments. Most small towns are either more recent adopters of commercial database products or have a quantity of data that is far more cost effective to manually transfer into a new system. The valuable lesson is that proprietary systems are far more costly and difficult to develop, debug and maintain. Many of these drawbacks are elaborated upon in the Navy case study presented later. Smaller users, such as local towns, should attempt to completely avoid proprietary software development and concentrate exclusively on the selection and use of commercially available software.

3.4.2 Commercial Maintenance Management Applications

Based on the early success of the proprietary asset management programs, software firms began to develop commercial maintenance management applications. These packages were intended to expand the user base to include medium-sized government and private infrastructure managers, thereby spreading development costs over numerous customers and providing more robust systems at a lower installed cost. Already in use by many large private companies, college campuses and public transportation authorities, these maintenance management applications provide the potential for using a commercial off-the-shelf (COTS) solution with a pre-existing support and development network. Generally these programs consist of a public works management core and a series of add-on modules for additional capabilities, all of which are tailored and customized to meet individual customer needs.

In response to the GASB 34 requirements, firms such as MRO Software, Inc. and Hansen Information Technologies have created add-on modules to implement both the standard and modified approaches, demonstrating the responsiveness that is a primary advantage of commercial software solutions. For local governments that are already using programs such as Hansen and MAXIMO®, the purchase of these add-on modules is obviously a preferred method for achieving GASB 34 compliance with minimal effort.

For local governments not already using these programs, the choice is by no means obvious. Because of the size, complexity and customization requirements of these enterprise software solutions, purchase and installation costs can be prohibitively expensive. Depending on the size of town public works operations and the types of options desired, implementation costs can easily approach $1 million. For example, the contract to add Hansen Publics Works software to an existing Hansen town management system in Sacramento, California cost $240,000.[10] Installation of MAXIMO® software at Naval Station Norfolk, VA, home of the U.S. Atlantic Fleet, cost $842,866.[11] For small local governments, such high up-front costs make the selection of commercial maintenance management applications unlikely, despite the additional capabilities and benefits of COTS packages.

3.4.3 Integration of COTS Software

A third option for the development of asset management systems is the combination and integration of several COTS products. Improvements in data standards and interoperability over the past decade, combined with the emergence of the Windows® PC as a dominant platform, makes this a viable option for users wishing to assemble simpler asset management systems. Governments can add the functions and outputs they deem necessary, without paying for powerful features and capabilities that are not desired.

In many cases, a large portion of the software required is already owned and in use by the cities and towns. Office software suites include powerful, fully-compatible spreadsheet and database programs. Computer Aided Design (CAD) and Graphical Information System (GIS) software are commonly in use by engineering and planning departments. As will be discussed and emphasized in future chapters, these types of programs can be linked to form the core of a basic asset management system for infrastructure portfolios. While the overall system costs will vary based on the specific software choices made and the amount of outside consultation time required, total implementation costs are likely to be an order of magnitude lower than the large commercial maintenance management applications. This can aid small users in justifying the option of pursuing the modified reporting approach.

3.5 Identifying Infrastructure Data Sources

As the Infrastructure Systems Development Research (ISDR) group at the Massachusetts Institute of Technology has examined various planning issues at small towns in Eastern Massachusetts, it has become obvious that many local governments do not fully account for their existing infrastructure assets. Data sources range from hand-drafted sewer and drainage plans dating from the 19th century era drawings to modern CAD and GIS files from recently completed projects. In several cases, details and data on entire networks of assets are unknown to the current users and maintainers of the systems. While such cases objectively confirm the need for reform measures similar to GASB 34, the invisibility of such systems is a major impediment to implementation of the modified approach.

Local governments with scattered, incomplete infrastructure asset information have a very strong incentive to select the standard approach. This is due to the fact that information on older assets and networks are difficult to determine, while infrastructure created in recent decades is more likely to have higher quality, readily available data. Selecting the standard approach will allow the governments to ignore assets built prior to 1980, greatly reducing the burden of creating inventories of older assets. This should prove especially true in geographic areas with a high percentage of older towns, such as New England. In order to encourage adoption of the modified approach, the ISDR group has sought to create a straightforward, easily implemented strategy to provide these governments a cost-effectively means to assemble portfolio data on these older asset networks. Solutions to the following issues are needed to allow effective compliance with GASB 34 modified requirements: documenting of physical asset characteristics, application of condition ratings, and linking of cost data.

3.5.1 Strategies to Document Physical Characteristics

Before investing resources of time and money on the development of a software strategy, the data integration team should first attempt to assess the difficulty and potential success of the future data collection effort. To accomplish this, the team must perform the following tasks:

- Select which asset networks will be reported under the modified approach and require complete portfolio data.
- Identify the physical characteristics (size, length, material, age, etc) needed to document each type of asset.
- Perform a summary review of all existing data sources to confirm that all required information is potentially contained within the disparate locations.
- Estimate the difficulty and cost involved with locating missing data, such as manually inspecting manholes to determine types of pipe material.

If these procedures indicate a high probability that the required information can be either located among the existing sources or collected at an acceptable cost, a strategy for data collection can be created. Appendix A presents the data collection strategy used to document the sewer system in the town of Winchester, Massachusetts for GASB 34 reporting. As a result of this work, three fundamental recommendations were developed. First, each data source should be independently and completely reviewed from start to finish. Second, care must be taken not to overlook unusual data sources, such as residential sewer connection cards that proved to be an almost exclusive source of pipe material data. Third, since conflicting data for the same networks may be present across multiple sources, an order of precedence for application of the data sources must be determined and thoroughly documented.

Application of this systematic approach to the identification and collection of infrastructure data has proven to be an effective, easily repeatable method for small towns. Chapter 6 and Appendix A both provide greater insight into potential collection strategies and time requirements.

3.5.2 Strategies to Assess and Document Infrastructure Condition

While creation of an accurate inventory of eligible assets is a key milestone, it is only the first phase of work needed to meet GASB 34 requirements. The second challenge is the requirement to assess and document the condition of infrastructure assets on a regular basis. Despite its presence as a cornerstone of any asset management system, GASB 34

provides very little guidance in this area. This lack of standardized evaluation and reporting criteria is an area of great concern to smaller users, many of whom do not currently utilize any formal systems or procedures. In its 2001 survey of twenty-two state infrastructure agencies, it was found that all pursuing the modified approach plan to use state-specific evaluation and rating procedures.[6] While development of town specific rating systems may not currently seem feasible, the selection and adoption of procedures used by large government entities is an obvious option.

Roads and Bridges

For roads and bridges, the adoption of state procedures has multiple benefits. First, local engineers and public works personnel are most likely already familiar with overall details of the state DOT rating and reporting system. Second, state-wide evaluation systems have already been refined to provide information acceptable to support issuance of bonds in the financial markets, providing automatic credibility to local financial statements. Third, many public universities have developed low-cost programs to support the use of state rating standards, such as the Road Surface Management System (RSMS) available from the University of New Hampshire Technology Transfer Center. With the ability to output data in standard spreadsheet and database file formats, many of these programs might be used to interface as an integral part of an asset management system.

Buildings & Property

While states are presently unlikely to have formal, large-scale evaluation procedures for buildings, towns merely have to look past them to federal agencies that manage large infrastructure portfolios. Such agencies include the General Services Administration (GSA) and the Department of Defense (DoD). The DoD alone controls over $750 billion in federal infrastructure assets.[12] Within the Department of the Navy, building condition is standardized and reported thorough the completion of regularly scheduled Building Envelope Maintenance Survey (BEMS) and Annual Inspection Summary (AIS) inspections. The instructions governing these inspections and rating systems, such as the NAVFAC MO-322: Inspection of Shore Facilities, are readily available online and could be easily adapted by local governments to support GASB 34 condition reporting.

Water, Sewer and Drainage Systems

Developing a condition rating methodology for piping systems is likely to be the most difficult for several reasons. First, direct examination of these systems is difficult, time consuming and expensive. Second, since most water and sewer systems are operated at a local level, finding large system managers with pre-existing condition rating systems to adapt is unlikely. Town engineers may perceive a need to develop their own internal rating systems for individual lines by weighting combinations of factors such as: system type, pipe material, age, relining history and quantity of recent repair requirements.

3.5.3 Strategies to Automate Cost Data

The final phase of GASB 34 modified reporting requires the calculation of estimated costs for maintenance and preservation. While adjusting historical spending levels for inflation would be the easiest method, the past neglect and chronic under-funding of infrastructure maintenance at the local level renders such calculations highly suspect. A better approach would be based on a percentage of asset replacement value, which is already widely accepted as a standard planning and performance measure. For example, the Navy sets the minimum real property maintenance funding required at 2.1% of replacement value[5], and uses this calculation to create initial estimates of yearly appropriation requests.

Calculations of asset replacement values for local infrastructure can be easily added to an in-house asset management system. The defining criteria, such as material types, sizes and quantities, should have already been incorporated in previous phases of development. The inclusion and linking of a separate cost database containing unit price data could allow the automatic calculation of asset replacement values, plus estimated renovation and reconstruction costs.

The difficultly comes in deciding how to locate and update the required data. Some potential sources of reliable cost data include:

- Commercial estimating software, such as RS Means CostWorks.
- Actual unit costs from recent repair and construction contracts.
- Pre-negotiated unit prices from standing indefinite-delivery, indefinite-quantity contracts.

3.6 Summary

If initial trends are taken at face value, it appears that local governments are hesitant to pursue the asset management system requirements of the GASB 34 modified approach. Existing options of large proprietary or commercial enterprise software solutions appear too complex and expensive to meet the needs of small towns and cities. However, an implementation strategy based on the integration of smaller off-the-shelf programs, combined with the adaptation of existing government condition rating systems, holds promise as flexible, cost-effective means of developing basic asset management systems.

Chapter 4 History & Drivers of Naval Infrastructure Management

4.1 Birth of Naval Infrastructure

In the early days of United States naval history, it was common practice for a fleet to be established only in reaction to wartime requirements. Rather than investing in the construction and upkeep of an established fighting fleet, merchant and mercenary ships were typically hired and commandeered to defend the coastal waters and trade routes. At the end of hostilities, financial support from Congress would be greatly reduced and the vessels returned to their civilian duties. While far from ideal, this boom and bust strategy was an obvious necessity for a under funded, fledgling nation.

As the U.S. grew larger and became more involved in protecting national interests beyond its borders, Congress recognized the need to establish and fund a standing navy. In 1794, the Armament Act authorized the construction of six frigates, including the USS Constitution.[13] With plans to operate a peacetime fleet, the need for permanent shore support facilities was created. In 1799, the Washington Navy Yard became the first shore establishment.[14] Following the creation of additional shipyards, the Bureau of Yards and Docks (BUDOCKS) was established in 1842, creating the forerunner of the current Naval Facilities Engineering Command (NAVFAC). Civil engineers were first commissioned as Naval Officers in 1867, growing from a force of 10 in 1881 to over 1600 in the early 1990s.

4.2 Growth in Times of War

The Spanish American War is credited with signaling the need for infrastructure expansion. In 1897 the Navy controlled only 18 shipyards and naval stations, with a combined public works value of $53 Million.[15] The additional complexity and maintenance requirements of the new steam powered warships, combined with the need for remote coaling stations, resulting in naval public works expanding to over $190 Million in infrastructure by 1913.

In 1916, at the start of World War I, the Bureau of Yards and Docks (BUDOCKS) comprised less than 40 engineers and draftsmen. By the time the armistice was signed in late-1918, the technical staff had grown to over 335. Over three years, emergency wartime construction had more than doubled the infrastructure portfolio to a total value of $469 Million. Due to this expansion, the core public works infrastructure of most naval bases on the eastern coast of the United States is now over 80 years old. In 1920, the historical trend to build for wartime and then neglect facilities support continued, with BUDOCKS technical staffing dropping from 335 to just over 70 personnel.

The massive naval construction efforts during World War II had perhaps the most profound effects on forcing the evolution of naval infrastructure management. First, the value of installed facilities and public works expanded twenty-fold to exceed $9 Billion.[16] Second, the two theater nature of the war drove construction of both east and west coast naval facilities. Third, the island-hopping campaign performed by the Seabees in the South Pacific resulted in establishment of numerous bases in the South Pacific. Finally, the terms of surrender provided the U.S. Navy with permanent overseas bases around the globe, from Italy to Japan. In less than a decade, naval infrastructure grew 2000% percent and became truly global.

Adjusting all values to a baseline of 2001 dollars[17], the rapid growth in naval infrastructure value is clearly demonstrated below:

Year	Value	2001 Value
1897	$53,000,000	$1,130,000,000
1913	$190,000,000	$3,390,000,000
1921	$469,000,000	$4,640,000,000
1945	$9,000,000,000	$88,200,000,000
2001	---	$132,100,000,000

Table 4.1: Naval Infrastructure Values

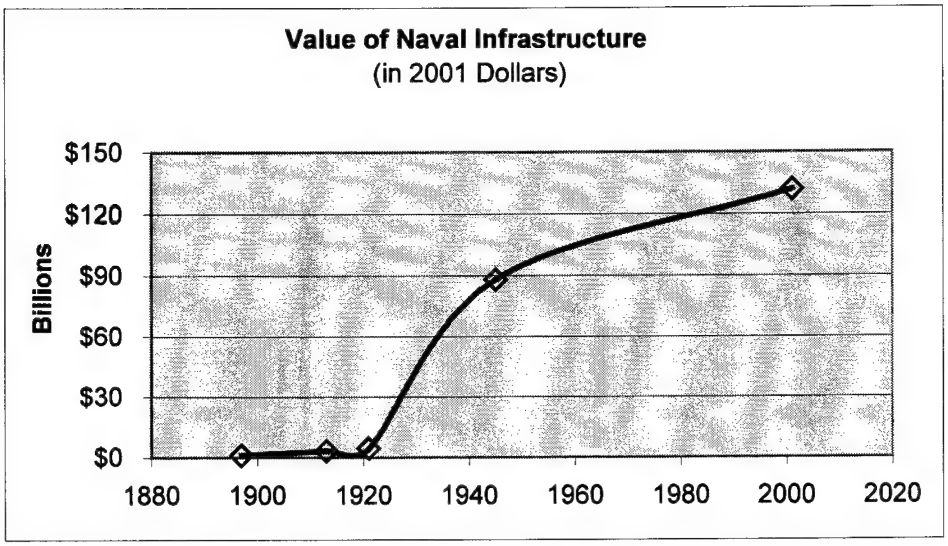


Figure 4.1: Plot of Naval Infrastructure Growth

4.3 Present Day Management Organization

Today, the Naval Facilities Engineering Command (NAVFAC) carries on as the direct successor to BUDOCKS. Comprising over 16,000 civilian and military personnel, NAVFAC manages and oversees over $8 billion in annual expenditures at more than 2,000 Navy and Marine Corp installations worldwide. Services provided include: development and planning, construction management, public works, utilities, base realignment and closure, environmental compliance, cargo handling, contingency engineering, real estate acquisition, military housing, ocean engineering and transportation management.[18]

The headquarters command, located at the Washington Navy Ward, employs 325 architects, engineers and contract specialists to provide program management, technical expertise and policy development. Eleven Engineering Field Divisions (EFDs) located around the globe provide regional engineering support and services. Nine Public Works Centers (PWCs) provide program management and support to individual base Public Works Departments (PWDs). The Navy Crane Center and Naval Facilities Engineering Service Center provide specialized research and technical support. Finally, two stateside Naval Construction Battalion Centers contain the in-house military construction force (Seabees) and provide contingency construction support.

Like any large, global corporation, NAVFAC has embraced information technology as a fundamental tool in the management of these and other diverse elements.

4.4 Key Portfolio Attributes

In comparison to even the largest of government agencies and private international firms, the size and composition of the Naval infrastructure portfolio creates physical challenges to effective asset management. As in any industry, as the level of complexity increases, so does the relative difficulty of maintaining control. Improvements in managerial strategies and processes, including the continual development and implementation of IT tools, are seen as key to improving the performance and condition of the NAVFAC facilities. Some of the key attributes of the portfolio include:

4.4.1 Global Distribution

U.S. Navy facilities are located throughout all corners of the world. From Iceland to the Persian Gulf, there are multi-billion dollar installations under the control of NAVFAC. While many large private firms may indeed have a global reach, with overseas marketing, distribution and production facilities become ever more common, few come close to covering the same vast array of countries and regions.

4.4.2 Variety of Infrastructure

Naval facilities are essentially nearly self-sufficient cities that contain a vast variety of infrastructure. Industrial, commercial, residential and specialized facilities are all managed as part of the same local and global infrastructure portfolio. From piers and airfields to housing and malls, the range of infrastructure types is unmatched by any public or private entity. Global corporations only have to focus on a limited subset of industrial or commercial facility types. Towns and cities also represent a variety of infrastructure types from treatment plants to roads and schools, but with far less quantity of each.

4.4.3 Interdependence

Individual naval bases are truly intended to operate as part of a larger whole. Specialized capabilities and operational missions, such as nuclear refueling and live weapons training, are spread among different bases in widely separated areas of the world. The inability of any one base to fulfill it's assigned mission can have devastating effects on Navy readiness and training as a whole. Problems at a remote plant of a multi-national corporation may jeopardize their portion of expected revenues and profit, but will rarely cause significant impacts to the operational performance of other plants and facilities run by the company. While this specialization is necessary to deal with both physical and economical constraints, it requires a much higher level of oversight and control over the construction, operation and maintenance of these bases.

4.5 Need for Information Technology

From the very introduction of the personal computer era, both the U.S. Navy and the Department of Defense (DoD) have focused a great deal on the development and integration of information technology (IT) in the Public Works environment. With over 16,000 personnel operating in a global, multi-level engineering organization, creating effective methods for communicating and sharing timely information is a constant challenge. While forty years of IT investment has brought varying levels of success at the local, regional and command level, complete asset management integration of Naval infrastructure continues to be an elusive goal.

Traditionally, the Navy has felt the need to embrace IT solutions due to the fundamental issues it faces as a major constructor, operator and maintainer of industrial infrastructure. As previously discussed, the Naval Facilities Command (NAVFAC) currently controls over $132 Billion in public works infrastructure at over 2,000 installations around the world. While dwarfed in comparison to the worldwide sum of all public and private infrastructure, the NAVFAC properties when examined as a whole comprise one of the single largest infrastructure portfolios ever assembled, creating significant challenges to effective asset management.

4.6 Drivers For Change

While the underlying physical attributes create a baseline demand for the improvements offered by IT enabled management tools, a large number of dynamic issues also serve as drivers for the implementation of these systems. Naval infrastructure management and planning does not occur in a vacuum, with changing regulations, societal influences and economic pressures all contributing to the relentless push for constant improvement. Either individually or in combination, the requirement to adjust to and meet the demands of the following systematic changes drive the need for further IT development within NAVFAC.

4.6.1 Environmental Regulations

Over the past thirty years, environmental concerns have steadily grown from an informal part of the internal infrastructure management process into a highly regulated, politically sensitive arena. Gone are the days when simply having an environmental engineer on staff to provide input during the project design process was adequate. Navy public works departments now contribute a major percentage of their available manpower and budgets to support in-house environmental departments. As this field continues to become more complex, greater use of IT tools are needed to keep pace with the changes in the following areas:

Land Use Tracking:

One of the key aspects of remaining in compliance with environmental regulations is to be able to understand and recognize the types, size and inter-relationships between the environmental zones within each base. Graphical Information System (GIS) tools such as ArcView have proven to be a useful and popular supplement to pre-existing Computer Aided Design (CAD) systems for maintaining and presenting this type of land use data.

Approval Authorities and Processes:

Before award, all public works projects must be screened to confirm whether any environmental permits or approvals are required. At the simplest extreme, this requires careful documentation of the reviews performed and decisions made even if further

approval steps are not warranted. At the opposite extreme, large, environmentally sensitive projects may face numerous local, regional and federal approval processes. This potential for complexity, combined with the large opportunity costs of delays, resubmissions and missed filing deadlines, drives a need for effective IT solutions for tracking and documenting the flow of environmental documents.

Windows of Opportunity:

Often, environmentally sensitive projects face outside political pressures at the local, state, or federal levels. While this sometimes creates difficulties in effectively managing the base infrastructure portfolios, it also provides an opportunity for effective IT solutions. Political and public sentiment towards issues can vary in strength significantly over time, which can create windows of opportunity for the approval of difficult projects. Being able to react quickly and effectively push through projects requires accurate, timely information. Again, IT tools are a key factor in being able to accurately track the current technical and administrative status of environmentally sensitive project issues.

4.6.2 Age of Naval Infrastructure

When examining the present day portfolio of Naval infrastructure, special attention must be paid to the age of the facilities. Throughout the 160 year history of the Navy Facilities Engineering Command (formerly the Bureau of Yards and Docks), historical size and growth has been anything but constant.

As previously discussed, wartime construction has been heavily influenced by progressive advances in the scope, technological demands and global reach of modern warfare. During the Spanish American War, the switch to more advanced coal fired ships drove an increase in naval infrastructure from $53 Million to $190 Million between 1897 and 1913. World War I saw the infrastructure portfolio more than double again to a total value of $469 Million. As a result, the core public works infrastructure of most naval bases on the eastern coast of the United States is now over 80 years old. However, this pales in comparison to the massive naval construction efforts during World War II, where the infrastructure expanded by over 200% to exceed $9 Billion. The majority of the

bases and facilities, including virtually all of the installations on the west coast of the U.S. and throughout Europe and Asia, are well over 50 years old.

Over the past 50 years, expansion and replacement of Naval infrastructure has generally been driven by regional conflicts. The Korean and Vietnam Wars drove construction at bases in Asia in the 1950s and 1960s. Similarly, the Gulf War resulted in major upgrades and expansion of U.S. Navy bases around the Mediterranean Sea, including facilities in Italy, Spain and Bahrain. The most recent newly constructed U.S. base, Naval Submarine Base Kings Bay, was completed in 1978 and is already approaching 25 years of operation.

In summary, the Navy is faced with an infrastructure portfolio that is increasingly old and has undergone only limited, regionally isolated improvements. Core base assets within the continental United States often exceed 80 years of operation, with most overseas locations in the range of 50 years, and both have temporary structures built during WW I and WWII that are sometimes still in active use. The average age of the total Navy infrastructure portfolio was 44 years in late-1999.[5] The increasing maintenance needs and costs of older structures demands advances in tracking, programming and planning to minimize their impact on total portfolio management costs.

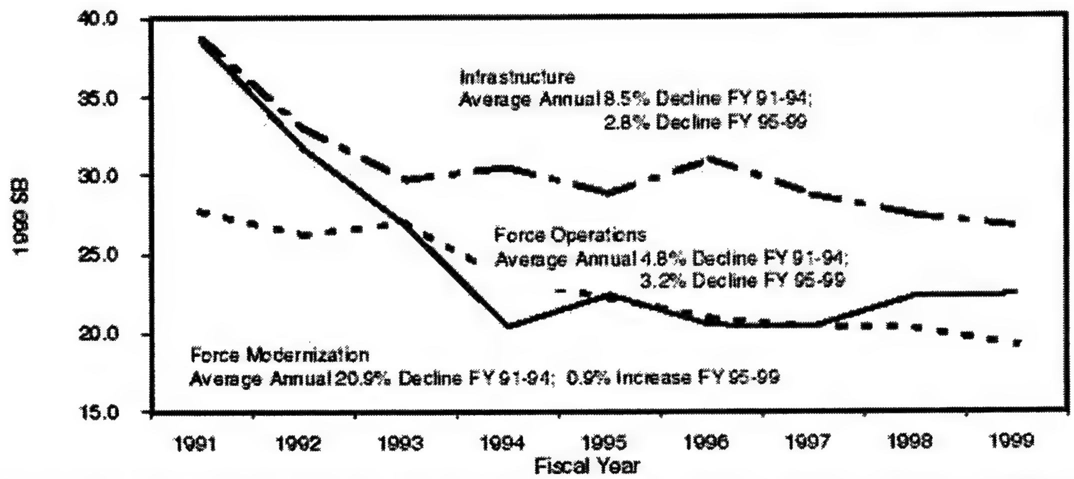
4.6.3 Base Realignment and Closure (BRAC)

In response to the steady decreases in force size and operational support requirements, Congress completed two rounds of Base Realignment and Closure during the 1990s. Intended to reduce the total size of the infrastructure portfolio to better meet future requirements, the program has required an average of $5.6 billion per year in spending over the last decade. In the first 4 years, over 997 outdated facilities totaling 6.9 million square feet were demolished, greatly reducing future operations and maintenance burdens. However, because of the economic implications of lost jobs in targeted areas, base closure continues to be a hotly contested political issue at local, state and federal levels. Better management and information systems are needed to more objectively

compare the costs, condition and relative performance of equivalent bases to insure the greatest future savings are realized.

4.6.4 Growing Backlog of Maintenance and Replacement

Since the end of the Cold War, the Navy has been forced by Congress to undergo significant reductions in size and annual budgets. From FY 1991 to FY 1999 the Navy budget was reduced by approximately $40 billion per year (33%), and is projected to continue declining at 1.4% per year.[4] This severity of this decline is shown in Figure 4.2 below:



Fiscal Year	1991	1992	1993	1994	1995	1996	1997	1998	1999
Modernization	38.6	31.7	26.8	20.4	22.4	20.5	20.4	22.3	22.4
Operations	27.7	26.2	27.0	23.3	22.2	20.9	20.4	20.3	19.2
Infrastructure	38.7	33.1	29.7	30.5	28.8	31.0	28.7	27.4	26.7
Total	105.0	91.0	83.5	74.2	73.4	72.4	69.5	70.0	68.3

Figure 4.2: Navy Budget Allocation Trends[4]

As shown, the Navy budget is split into appropriations for Operations, Infrastructure and Modernization. During a period of downsizing, the operations budget will naturally decrease due to the reduced personnel and salary costs. Infrastructure, however, involves long-term fixed costs and O&M expenses that do not automatically react to reductions in manpower or building utilization rates. As a result, the Navy was forced to sacrifice modernization spending at a rate 2 to 3 times greater than infrastructure cuts from FY 1991 to FY 1994, severely jeopardizing future force capabilities.

In response to demands for modernization funding, the Navy has been forced to under-fund public works activities over the past half-decade. While a backlog of maintenance and replacement work has always existed, the situation has grown worse at a rapid rate. With expenditures DoD wide only covering approximately 80% of the funding necessary for maintenance and repair, the backlog of deferred maintenance has reached an estimated $16 billion.[19]

4.6.5 Outsourcing, Staff Cuts and Regionalization

Over the past decade, a major shift has occurred in the operation of base public works departments. For most of its history, Navy infrastructure was supported and maintained primarily by government civilian employees. The full spectrum of O&M activities from planning and estimating through purchasing and work completion was performed by an in-house workforce. The past decade of budget cuts has driven both a radical shift towards the outsourcing of O&M operations and major reductions in local support personnel. To compensate, regionalization has formed 8 Installation Management Claimants (IMCs) to manage and optimize the support and mission requirements of all bases within selected regions. This shift of technical expertise and decision authority to higher levels demands a greater flow of timely, detailed facilities data that is more consistent between bases. This provides yet another driver for the development of better IT tools for infrastructure management.

Chapter 5 Case Study: Naval Shipyard Portsmouth & Smart Base

5.1 Background

Naval Shipyard Portsmouth is one of the Navy's oldest operating shipyards. Founded on June 12, 1800, the base is located in Kittery, Maine at the mouth of the Piscataqua River. From overhauling the USS Constitution in 1857 to building the first diesel and nuclear powered submarines, the shipyard has serve as a key piece of naval infrastructure for over 2 centuries. Employing over 3,000 personnel performing $400 million in annual revenue, the base is comprised of two distinct sections. The industrial and administrative infrastructure is located on an island, while a separate 234 unit housing community located on the mainland. Originally tasked with the maintenance and refitting of wooden sailing vessels, the mission of the shipyard has evolved over time. Currently, NSY Portsmouth is one of only four remaining Navy shipyards and specializes in performing nuclear refueling and overhaul services for fast attack and ballistic missile submarines.

Many unique characteristics of NSY Portsmouth combine to make this an ideal location for improvements in infrastructure management tools. The age of the base creates the problems of extremely old core infrastructure combined with historically significant properties. The 200 year industrial history results in issues with past pollution and environmental remediation concerns. The highly sensitive nature of the nuclear submarine work makes outsourcing difficult and results in a larger than normal number of government public works employees, requiring better work and personnel tracking abilities. Finally, the large amount of in-house projects and maintenance work requires the presence of a larger, more technically diverse PWD engineering staff. With one of the most challenging, operationally focused infrastructure portfolios in the Navy, NSY Portsmouth has a vested interested in working to develop and implement improved asset management systems.

5.2 Learning from the Strategies of the Past

As some of the largest infrastructure managers in the world, the Department of Defense and U.S. Navy have a long history of pushing the envelope and becoming early adopters of information technology. For over three decades, government computing initiatives have slowly pushed larger and more powerful applications down to the lowest level of the organization. Early use of mainframe computer to maintain limited data at the highest levels expanded to the use of crude databases at the regional levels. The advent of mini and micro-computers drove the creation of data programs and work tracking software at the installation level. However, gradual progression of programming languages and computing hardware platforms resulted in a proliferation of independent, non-compatible systems. Additional computing power has so far failed to achieve the ultimate goal of seamless information exchange throughout the NAVFAC chain of command. With the advent of the Smart Base initiative, the Navy is seeking to avoid the limiting strategies of the past and build an information infrastructure for the 21st century.

5.3 Past Software Strategies

The Navy strategy for the developments and implementation of public works management software can be separated into two distinct eras. From the early days of the non-mainframe computing until recent years, the trend was to pursue the development of customized, proprietary software systems. Federal acquisition guidelines meant to foster the growth of competition and support small businesses inadvertently discouraged the widespread adoption and use of standardized commercial software programs. Over the past decade, changes in these regulations have allowed a shift to best-value procurement strategies and opened a new era characterized by the embracing of large, commercial enterprise software tools.

5.3.1 Proprietary / MILSPEC Systems

It is a well known fact that defense research and development (R&D) spending has a long history of creating and nurturing emergent technologies. The creation of new weapons systems, designed to meet proprietary military specifications (MILSPECs), often prove the feasibility and usefulness of new technologies, paving the way for later commercial

development and implementation. For the better part of two decades, the governments role in information technology has followed the same pattern. Early computer technology was expensive and unproven, hindering the development of commercially viable software. Along with large government agencies such as the IRS, the Department of Defense took a lead in commissioning the early development of management software. Development costs that would have been impossible for even the largest of cities to justify were effectively spread among the Navy's vast portfolio of infrastructure and bases. While the development of these proprietary systems was the only viable options in the early days of computer adoption, this strategy created a series of long-term issues.

Consensus Design:

One of the key justifications for proprietary technology development was that the significant initial investment costs could be leveraged over a large number of Navy installations. This diverse user base, combined with the requirements to ensure responsible use of significant amounts of public funds, resulted in need for large committees to develop program goals and specifications. Unfortunately, such management by committee tends to seek safe solutions, stifling unique ideas and innovative approaches. The results are consensus design standards that focus on automating existing management practices and procedures, rather than striving to use information technology to reinvent the system. Thus in these older proprietary systems, the software was made to fit the practices, rather than used to reinvent the process.

Legacy Systems:

Over the past three decades, computer hardware, software and operating standards have undergone constant change. Some technologies thrive, many are quickly rendered obsolete, but all are eventually surpassed and replaced. Even with the emerging dominance of the Windows PC over the past decade, competing technologies continue to develop and advance at a rapid pace.

As an early purchaser and developer of information technology, the Navy has procured public works management tools using a wide range of technologies. Each new system

would sought to use the best technology of the time, taking advantage of more powerful hardware and software. The end result was a series of incompatible software programs running on different hardware platforms and developed in a variety of programming languages. Some, such as UNIX, have remained supported standards, while others like Fortran have not. Many of the earlier infrastructure management programs now run on obsolete, unsupported technology platforms. These legacy systems are a major problem, due to both data compatibility issues and the difficulty in performing repairs.

Failure to Update and Switch to Commercial Alternatives:

Historically, the use of proprietary systems has discouraged further investments in necessary updates and improvements. Due to the custom nature of the programming and software, performing major updates often proves almost as expensive as the initial development effort. In addition, newer technology has usually been introduced in the interim, making reinvestment in the outdated systems undesirable.

Ideally, government IT investments should result in the discovery of viable uses for technology, driving the commercial development of infrastructure management tools. While this spin-off concept has proven successful, there has been an unfortunate tendency to continue using and developing proprietary systems well after viable commercial systems have been developed. An example is the CBCM construction project management software in use by the Navy Seabees. Originally based on the manual project planning procedures used from WWII through Vietnam, CBCM was developed as a proprietary DOS-based software program to produce project tracking reports and Gant charts. Following this proof-of-concept application, future years saw the development and refinement of commercial products such as Primavera and Microsoft Project. Instead of adapting these more robust and less expensive products, thereby taking advantage of the commercial development cycle, the Navy continues to update and debug the proprietary CBCM software on a sporadic basis, missing out on the potential benefits of its pioneering development work.

5.3.2 Commercial Maintenance Management Applications

Over the past 5 years, the Navy's approach to information technology procurement has undergone significant change. In the past, the Federal Acquisition Regulations (FAR) discouraged the use of large, exclusive contracts for computer hardware and software. Recognizing its role as one of the largest IT customers, the government sought to discourage the use of sole-source procurements in order to foster competition and innovation among a larger number of firms. This policy resulted in the use of a variety of hardware platforms, word processors, database programs and other software, which hindered attempts at standardization within bases, regions, and across the organization. A gradual shift to pre-qualification and selection of a limited list of products in each category was an improvement, but still relied on low bidding and prevented full standardization. Recently, the emergence of "best value" procurement practices has brought about competitive software procurement based on technical evaluation factors and the issuance of long-term, sole-source contracts.

NAVFAC has seized upon these procurement changes as an opportunity to move away from the proprietary infrastructure management systems of the past. In January 1995, the Facilities Working Group (FWG) was formed to examine the feasibility of standardizing facility management standards throughout the Army, Navy, Air Force, Marines, Coast Guard, Corp of Engineers, Defense Logistics Agency, General Services Administration and Department of State. Focus was placed on the possibility of utilizing commercially available enterprise asset management software solutions. Already in use by large private companies, college campuses and public transportation authorities, these maintenance management applications provided the potential for an off-the-shelf solution with a pre-existing support and development network. Generally these programs consist of a public works management core and a series of add-on modules for additional capabilities, which are then tailored and customized to meet individual customer needs. Based on FWG recommendations, the Navy chose to adopt the MAXIMO® software suite from MRO Software, Inc. to manage its global infrastructure portfolio and public works operations. After several years of implementation efforts, several potential issues have become evident.

Difficulty in Implementation:

Despite the commercial nature of the MAXIMO® software, each application must be custom tailored to the base where it is installed. As previously discussed, Navy bases encompass great variations in size, age and operational requirements. The difference in needs between a 200 year old shipyard with in-house public works personnel and a 50 year old foreign air station with out-sourced maintenance contracts present a significant challenge in adapting the software. Additionally, the wide variation in the quality of the proprietary systems already in use complicates the transfer of data and replication of pre-existing functions in the new MAXIMO® database. Finally, inherent conflicts exist between customization requirements and the desire to standardize outputs throughout the organization for use at higher management levels.

Steep Learning Curve and Training Requirements:

Large integrated software solutions such as MAXIMO® result in a steep learning curve that must be overcome when intially implemented. First, existing systems are often comprised of a series of smaller, individual programs with a few users familiar with each. The size of the new program can appear overwhelming to users, even if they only need to interface with a small portion of the system. Second, the implementation goal of a clean, rapid break from the old systems to the new creates a high level of pressure on both the programmers and users. Third, the additional features and complexity drive a need for more advanced, in-depth training. This creates difficulties at smaller bases with limited public works personnel and forward-deployed Seabee bases where operational personnel are frequently rotated, hindering effective mastery of the MAXIMO® software.

Cost:

Although commercial development allows R&D costs to be spread over a larger customer base, the size and complexity of the MAXIMO® software still results in significant installation costs. Depending on the size and complexity of the public works operations at an installation, implementation costs can approach $1 million. For example, installation at the Army Garrison at Fort Monmouth, NJ, with only 20 to 30 heavy users,

cost $380,000 in 1996. However, installation at Naval Station Norfolk, VA, home of the U.S. Atlantic Fleet, cost $842,866.[11]

5.4 Creation of the Smart Base Project

"If we were to go back in time 100 years and ask a farmer what he'd like if he could have anything, he'd probably tell us he wanted a horse that was twice as strong and ate half as many oats. He would not tell us he wanted a tractor. Technology changes things so fast that many people aren't sure what the best solutions to their problems might be"[20]

The implementation history of IT technology for Navy infrastructure management reveals limited systematic innovation. As discussed, proprietary systems were developed with an eye towards making the software fit the existing practices, resulting in automation rather than innovation. Use of commercial maintenance management applications, such as MAXIMO®, limited flexibility by requiring that some practices be modified to fit the structure of the software. In 1996, the Navy Smart Base Project Office was chartered under the Director of Shore Installation Management to support the Chief of Naval Operations (CNO) directed Defense Reform Initiative. The mission of Smart Base is "to identify, demonstrate and promote innovative solutions that apply proven state-of-the-market technologies and business practices that will increase shore installation efficiency, maintain readiness, and reduce the cost of infrastructure."[21]

Structured as a demonstration project, Smart Base grew out of the realization that universal technology solutions did not always meet the needs of individual installations. The two pilot sites, Naval Station Pascagoula, MS and Naval Shipyard Portsmouth, NH, were directed to take a business approach in identifying more beneficial combinations of commercial off-the-shelf, non-developmental information management solutions. Similar to the earlier MAXIMO® initiative, the goal for public works management was to coordinate sharing of data, allow migration from multiple legacy systems, and support integration of management at the base and regional levels. In order to support the goal of implementing any solutions developed at up to 25 similarly sized bases, the pilot sites were required to document: alternatives identified, time and money spent for

implementation, expected return on investment (ROI), and support of data integration requirements.

5.5 Choosing Goals for the Smart Base Project

According to the current 5-year strategic plan, NAVFAC leadership seeks to "apply advanced web-based Information Technology to reduce costs, improve management decisions, leverage resources, and foster interdependency."[22] The Smart Base projects play a key role in determining the feasibility of local software integration efforts and have the potential to alter the course of future Navy IT procurement strategy. To meet both the CNO and NAVFAC objectives and insure the development of successful systems, careful consideration had to be given to identifying both the type of system architecture to be created and the nature of the processes to be improved.

5.5.1 Selecting Overall System Criteria

Because of its role as a demonstration project, the Smart Base project at Portsmouth began with a clean-sheet-of-paper approach. Unlike previous IT initiatives, where management decisions at higher levels dictated both the scope and outputs, the public works department had no pre-determined constraints on users, data or desired functions. While a source of great opportunity, this open-ended challenge required significant up-front effort to identify potential areas for improvement and desired system criteria. Mr. John Wyeth, the PWD civilian Chief Engineer, assembled and led a multi-disciplinary team tasked with drafting the outline of NSY Portsmouth's Smart Base project. The early sessions identified four key criteria that would characterize the system development.

<u>*Low Cost:*</u>

While budgetary constraints are always a factor in any project, they were an even more fundamental part of the Smart Base concept. The Navy was not willing to finance a high-cost public works IT project, as NAVFAC had already spent considerable time and effort identifying and selecting MAXIMO® as the standard one-stop solution. Using the Smart Base initiative to develop a large, expensive, proprietary system would have ignored the

lessons of the past and wasted valuable resources to needlessly compete with the pre-approved MAXIMO® option. In support of the grass-roots nature of Smart Base, NSY Portsmouth was provided with limited initial program funding.

Operate on Existing IT Network:

The requirement that any software-based solution operate within the constraints of the existing public works IT network was driven by two factors. First, the limited amount of funding did not allow enough margin to cover the procurement of significant hardware upgrades. Second, the existing public works network server was already several years old and not scheduled for replacement for at least another year. Existing software and data application implemented over the previous few years had already begun to tax the processing and storage capacity of the server, leaving limited capability to handle a large, centralized new software or data application. As will be shown, these constraints had perhaps the most profound effect on the structural development of the system architecture.

Flexibility:

Maintaining the flexibility to easily modify and adapt the management tools developed under Smart Base at the local level using in-house IT personnel was viewed as critical. Extensive use of outside consultants and software technicians would quickly overwhelm the limited project funding. In addition, the directive to envision and create new facility management tools would likely lead to a much more iterative development process, with features being added, tested, revised and sometimes removed based on continued feedback from users. The requirement to target the new system towards supporting external public works customers as the primary users would result in a much more diverse user base for feedback. Unlike an internal system whose development could be closely guided and controlled by a small group of proficient end-users, trying to predict and cater to the demands of outside users requires a far greater level of experimentation and revision. Finally, the secondary Smart Base goal of NAVFAC taking the best concepts developed at the test sites and adapting them for use at other naval bases needed

to be considered. This required the flexibility to easily adapt the IT tools to account for physical and administrative variations between different installations.

Scalability:

Closely related to the flexibility requirement was the need for a highly scalable system. At its inception, the Smart Base system would begin with a core base of data, users and functions. It was envisioned that strong demand would drive the need to expand the effort and allow the project to evolve into a set of increasingly useful tools, serving more users with a greater array of data. A strategy was needed that would allow this future growth to be accommodated within the structure of the IT hardware and software.

5.5.2 Selecting the Focus Areas

Perhaps the greatest challenge at the outset of the Smart Base project was the identification and selection of a facilities management issue upon which to focus the development efforts. Unlike large enterprise software solutions such as MAXIMO® that inherently cover a wide range of public works functional areas all at once, the restraints of developing an in-house system mandated the addition of functions in stages. Clearly identifying areas to address, understanding the relationship between them and formulating a clear development strategy was viewed as critical. After conducting extensive reviews of both customer interactions with PWD and internal work routing processes, four functional areas were targeted.

Work Order Requests:

Operating under the mandate that Smart Base solutions were to utilize web-based tools to automate and process customer interactions more efficiently, the development team focused on identifying and analyzing the most common sources and types of customer contact. The reporting of maintenance trouble calls to PWD was quickly identified as comprising the vast majority of contact with external customers. Examination revealed the existing processes to be inefficient and a source of unnecessary frustration to both customers and public works personnel. The existing system was almost completely manual, relying on building managers, initial phone contact, a stand-alone database,

frequent on-site visits to clarify the repair locations, and paper-based routing of estimating and funding. As discussed later in the chapter, the creation of a web-based tool to automate the submission of work order requests by customers was selected to be the first phase of Smart Base development.

Internal Approval, Design, Estimating & Funding Routing:

Once a work order request was submitted by an outside customer, it became part of a stand-alone database of outstanding maintenance. With the exception of emergency safety issues, the request would be reviewed at a weekly planning meeting to determine which requests could proceed to the engineering department for review, design and estimating. Only then was it handed over to the finance department and entered into a stand-alone funding request database. This routing was entirely done with hard-copy paper documents, preventing intermediate tracking of the work orders and creating a high level of frustration for customers anxious to learn the status of their repair requests. A computer based internal routing and tracking system for the design, estimating and funding process was therefore selected to be the second phase of Smart Base system development.

Facility Condition Data:

While the presence of accurate, informative facility condition data is of great value to local PWD planners, such information actually plays a much bigger role in the overall scheme of Navy facility management. As part of the NAVFAC budget allocation process, the production of standardized infrastructure condition assessments for individual installations is a critical, time-sensitive reporting requirement. "At higher levels, programs are evaluated not only on need, but on mission readiness impact while recognizing available resources cannot fully fund all programs. Documentation of real property condition and its effect on operational readiness is critical in justifying budget requests."[23] Condition data is analyzed and compared at the regional level to allocate funding for maintenance and minor construction projects among competing installations. At the highest levels, regional condition data is further aggregated to aid the development

and support of the overall Navy budget requests for both O&M and Military Construction (MILCON) funding from Congress.

The NAVFAC MO-322 Manual, "Inspection of Shore Facilities", fully details the inspection methodology, frequency and reporting requires for a wide range of Navy facility inspections. For the purpose of the Smart Base development at Portsmouth, focus was placed on the data required to generate the two most in-depth reports, the Building Envelope Maintenance Survey (BEMS) and the Annual Inspection Summary (AIS). The BEMS are conducted on individual buildings every few years and comprise a complete assessment and rating of the structure and major systems. The AIS is a an annual report produced to provide a snapshot of overall facilities conditions, maintenance backlog, repair costs and operational impact for every Naval installation. Historically, both of these reports were generated manually using both hard copy inspection sheets and several stand-alone database of work requests and cost estimates. The integration of these data sources had the potential to improve both the accuracy and timeliness of these reports, while also allowing access to more frequent updates of this valuable planning information, and was selected to be the third phase of Smart Base system development.

Financial Forecasting:

As envisioned by the PWD development team, the ability to ultimately automate the financial forecasting process was a seen as the ultimate key to developing a high-value Knowledge Management System. Unlike the commercial programs such as MAXIMO®, where this type of function is one of the first features used to justify the high implementation cost, the external customer-driven focus of the Smart Base initiative dictated that the addition of these functions occur in later phases of development.

5.6 Designing the System

With the identification of the development phases and general system constraints complete, the PWD project team focused on identifying and analyzing which pre-existing data sources to integrate. In addition, initial concepts for the type of user interface began to be examined. It quickly became obvious to the team that for any system to gain the

support of the external customers, there would need to be both a user-friendly graphical front-end and complete access to data throughout the entire processing chain.

5.6.1 Strategy Development

While several team members were familiar with various GIS and database products on the market, no internal expertise existed in the integration of such products. Realizing the need for an outside source of expert guidance, a consulting relationship was initiated with Applied Geographics, Inc. (AGI), a GIS services company out of Boston, Massachusetts. Specializing in the creation of spatially-enable intranets and Web-sites, AGI played a key roll in developing the 3-point software strategy for the Smart Base information management system:

1) Build the most useful, visual tools for the outside customers first.
2) Use a small program to interface with the existing data sources, instead of trying to integrate all the databases into one large entity.
3) Phase in additional functions as the time, budget and debugging efforts allow.

Of these, the decision to interface with existing databases proved to be the most influential to the development path of the system. Conventional wisdom for building knowledge management systems typically calls for the conversion, standardization and integration of disparate data sources, as pursued by the commercial products such as MAXIMO®. However, the network and funding constraints drove the adoption of this alternative interfacing strategy, which will be discussed in depth later.

5.6.2 Identifying Key Data Sources for Integration & Software Tools

At the most basic level, two types of data sources are required to build the type of graphically driven system envisioned by the PWD team and AGI. Graphical facilities information was needed to make the front-end of the system user-friendly, while tabular data sources would provide the bulk of information to make the system a useful tool.

Graphical Data Source:

Two potential sources of graphical facilities data existed at NSY Portsmouth. These were GIS base maps completed in ArcView and CAD drawings in AutoCAD 2000 format. The selection between the two sources would have a major impact on both the development difficulty and potential usefulness of the Smart Base project. Selecting the ArcView files as the graphical data core would have proven much easier to implement, given the greatly reduced level of detail, limited number of files and layers, and the built in database functions contained in the software. However, a significant trade-off would have been the inability to provide users with an acceptable level of detail on individual facilities, which would have severely limited the work order requestors ability to adequately identify location of problem areas and required PWD the planning and estimating staff to continue the practice of routing hard-copies of AutoCAD drawings.

When the development process began, the PWD engineering department was nearing completion of a multi-year effort to digitize all the base facility drawings into AutoCAD files. Utilizing the recent Tri-Service Standards endorsed by the DoD, significant time and money had already been spent on revising pre-existing CAD files to exhibit a high degree of standardization, paving the way for accurate, reliable sharing of CAD data with other programs. The public works leadership desired that this new library of AutoCAD files form the core of the information system for several of reasons. It would provide a greater return on the previous investment, allow customers to identify problem areas with far greater detail, and eliminate the need for the planners and estimators to route separate hard-copy drawings through the work order routing process.

The NSY Portsmouth public works department already owned licensed copies of ArcView software, purchased in support of previous environmental mapping initiatives. Although the built-in database capability and lower list price of $1,500 per copy were beneficial, the level of detail provided would not have been adequate to support the desired level of graphical interfacing and data envisioned. Based on guidance provide by AGI, the project team decided instead to purchase MapObjects, a more sophisticated GIS program also offered by ESRI Software. Although more expensive at $5,000 per copy,

MapObjects boasts compatibility with a wider range of existing data sources and the ability to combine multiple data sources across the Internet and intranet environments.

Existing Databases:

As previously discussed, the existing PWD processes were supported by a disparate collection of stand-alone databases. In addition to the separate Work Order Request and Funding databases, each engineering discipline maintained separate spreadsheets and databases of details pertaining to individual infrastructure systems. Employees specializing in separate areas, such as roofing, HVAC, water / sewer and underground electrical utilities, each maintained their own sets of data to support their design, planning and estimating work. The majority of these data sources were kept in either Microsoft Access or Excel formats, while a few sets of data were still maintained in older version of competing programs such as Dbase and FoxPro. Because of these separate data "kingdoms", progression of work orders through the planning and estimating process required either direct consultation with the keepers of the necessary databases or a physical hand-off of the package between employees. However, the separate ownership of these data sets also brought with them a dedicated set of users with a strong internal motivation to insure the continued accuracy and updating of the information.

A key decision that needed to be made by the project team was whether these existing sources should be converted to a single file format and stored in a large, central database or if a smaller central program should be used to search out and interface with the existing data sources on the network. The primary benefits and drawbacks identified for each method are presented in following table:

Integration Strategy	Interfacing (Sharing) Strategy
PRO: - Reduced future software compatibility / upgrade issues. - Centralized data backup.	PRO: - IT demands spread over existing network. - Data providers maintain "ownership" of their databases. - Updating responsibility remains with data source owner. - Prevents unauthorized / accidental changes to data by other users. - Easier to add new data sources.
CON: - Requires more powerful server with increased data storage. - Data providers lose feeling of "ownership" and responsibility over data. - All data providers must be forced to switch to the new system, even if they're not end-users. - Multiple access levels are required to limit and regulate changing of data.	CON: - Strong coordination required among individual data source providers. - More IT hardware / software types. - Future compatibility of older database programs. - Difficulty assuring data backup.

Table 5.1: Comparison of Integration vs. Interfacing of Data Sources

5.6.3 Establishing Internal Control Measures

With the successful selection of a strategy built around using MapObjects software to interface with the pre-existing data sources over the PWD intranet, the issues of standardization and control over changes needed to be addressed. According to guidance from the US DOT, "although it is not necessary to store all the transportation system's data in a single repository, it is critical that the data be readily accessible and comparable."[8] By allowing the databases to remain under the separate control of the primary data providers, a common methodology to link them had to be developed. In addition, procedures needed to be created to ensure that changes or additions made to the databases would not adversely affect the operation of other parts of the Smart Base system. In order to achieve this, each existing data source was examined by the project team to document both the structural relationships and key data contained.

Selection of Primary Key:

As the first step in successfully linking the disparate sets of databases, a common "primary key" had to be identified. It was determined that the Building Number should be used as the key identifier link between all the data sources. There were several strong reasons for this selection, including:

- The large quantity and geographic density of buildings within the base.
- The existence of an existing numbering scheme for all buildings.
- The fact that utility systems exist to service the buildings.
- The need to report AIS and BEMS data by building.

For the majority of the databases, the selection of this primary key only required identification of the column containing the data and a careful check that all the building numbers and naming convention were consistent. For other databases, such as sewer and electrical manholes, columns identifying the nearest building had to be added to each row of data.

Establishment of Bi-weekly Data Group Meetings:

Creating the necessary level of coordination between all the data source providers required a two-step approach. First, each member was required to sign a memorandum of understanding promising that certain rules would be followed: database file names were to remain constant, storage location within the network would not be changed, and the database structures would not undergo additions or deletions without prior notice to the Smart Base coordinator. Second, in order to support the continued standardization of the sources, a bi-weekly meeting was established for key data users and suppliers. With it's primary purpose being to allow the discussion of proposed database changes in advance of implementation, the goal was to maintain the integrity of the data links within the work order request system indefinitely.

5.7 Implementation Experiences

With the selection of MapObjects software as the central integrator between the PWD AutoCAD files and the separate pre-existing databases, work could begin on the development of the Smart Base system user interface.

5.7.1 Phase 1: Web-based Work Order Request Entry

Over the course of the following months, a web-based work order request tool was created for the reporting of facility maintenance issues. To ensure both the safety of the proprietary public works data and the successful acceptance of the system by outside customers, the following steps were taken:

- A secure web-site was established under the PWD server.
- Login IDs and passwords were provided to a users at selected buildings who expressed high levels of interest and support.
- The system was made optional and temporarily run alongside the existing call-in trouble desk.

The trial system roll-out that resulted had several key benefits. First, the lower number of initial system users reduced the training burden. Second, the gradual addition of covered buildings and infrastructure systems kept the universe of linked data smaller during the early trouble-shooting stages. In addition, it allowed additional time for the engineering and drafting personnel to enter and link files, reducing time constraints and insuring greater accuracy and quality control. Third, the ability to utilize the old procedures as a back-up reduced frustration levels for the test users and provided the opportunity to demonstrate a side-by-side comparison of the advantages offered by the Smart Base system.

As a result of the thorough planning and clear definition of goals, the work order entry system experienced only minimal glitches during the initial tests. After only a few months of testing, the following requirements were implemented:

- All base facilities had to identify and register users.
- Use of the web-based system was made mandatory, eliminating the call-in option.

Through the integration of MapObjects, AutoCAD and Excel software, the number of steps and complexity of the work order process were greatly reduced, boosting efficiency.

Initial Work Order Request Reporting Process:

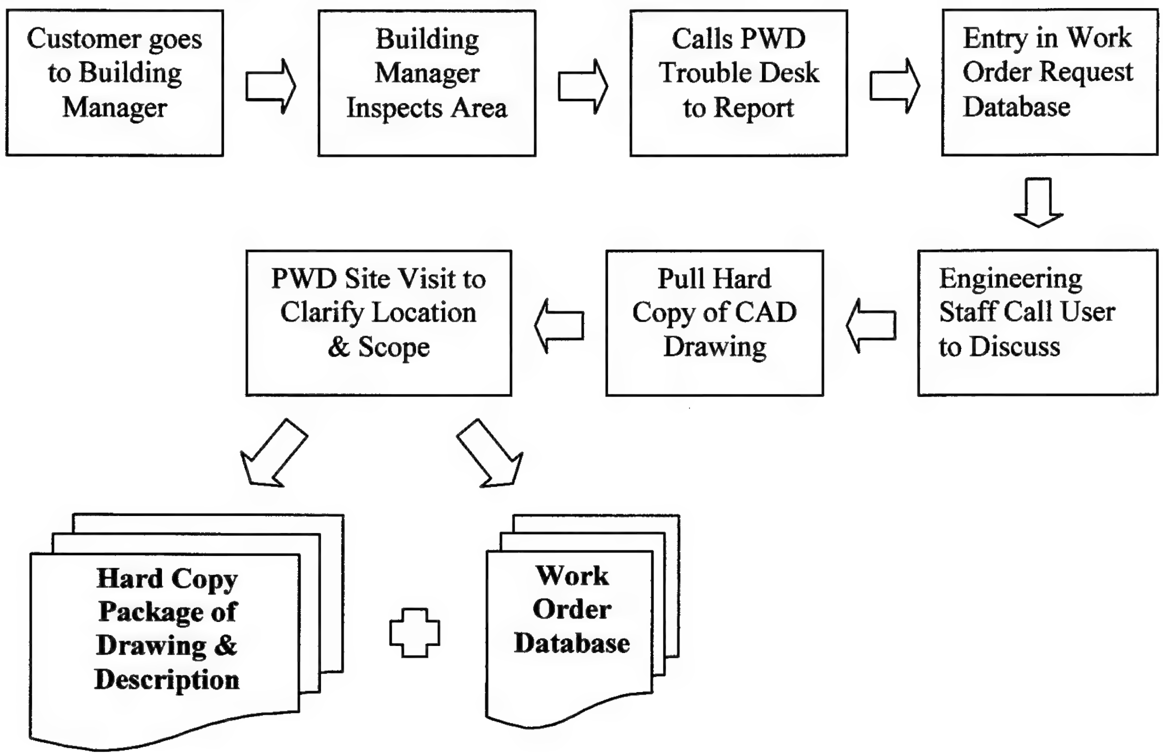


Figure 5.1: Pre-Existing Reporting Process

Smart Base Reporting Process:

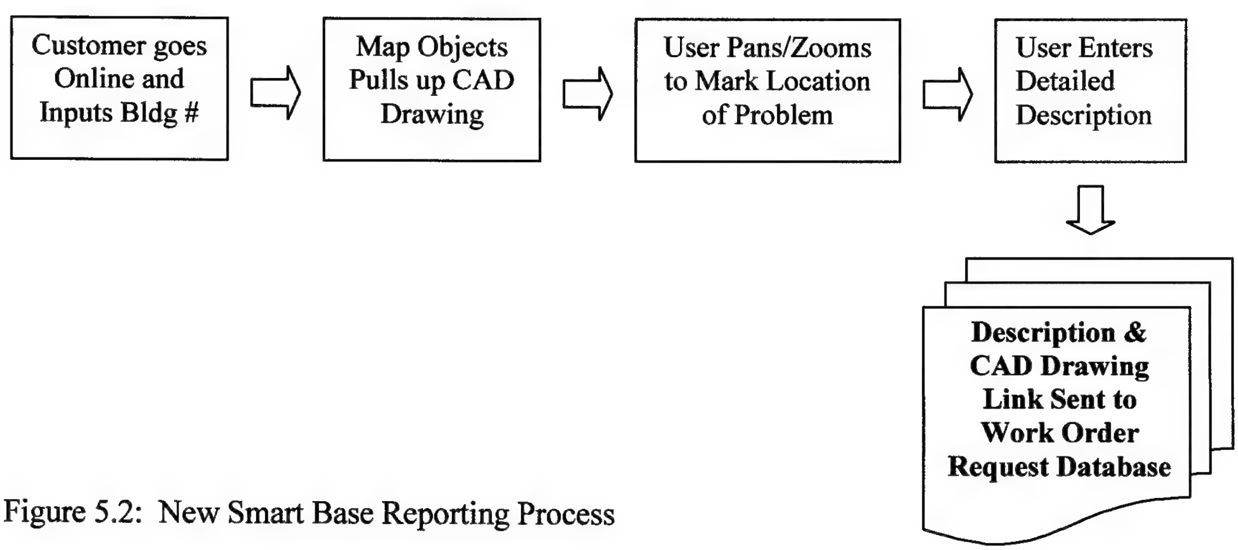


Figure 5.2: New Smart Base Reporting Process

5.7.2 Phase 2: Internal Routing & Tracking

With the successful completion of Phase 1 of the Smart Base system, the foundation was in place for the development of the next set of functions. As described previously, the progression of work order requests through the selection, planning, estimating and funding steps was a manual, paper-based process. The goals for this phase included:

- Paperless files for basic planning and estimating.
- Clear identification of personnel responsible for each work request.
- Easy tracking of package progression and current point-of-contact.

Paperless Files:

The decision to use of the MapObjects, AutoCAD and Microsoft Access software as the core of the work order entry system provided all the tools necessary to allow the design of a basic routing system. Along with being able to use the MapObjects driven interface to select floorplans, pan and zoom within the CAD drawings of their buildings, the external users were able to physically mark the location of the problems being reported. MapObjects allows this by linking the marking info to be saved on a separate layer linked to the coordinates of the original CAD plans, without changing the actual AutoCAD files. This same ability allows the planning, design and estimating personnel to make sketches, notes and comments directly on the routed data files, without the need to create and hand-off the traditional hard-copy work request packets.

Identification of Responsible Personnel:

At the weekly planning meeting, PWD managers determined which non-emergency work order requests would proceed to the planning and estimating department. Traditionally, department heads would divide the requests among the various engineers in the primary discipline, placing them in charge of creating the design packages and pushing them through the department. This method made it impossible for department heads to quickly determine which engineers from supporting disciplines were later tasked or how far the work request had progressed. A new routing database was created and interfaced into the Smart Base system, allowing the department managers to enter the numeric codes of the

primary engineer. The primary engineer could then enter the codes of all other engineers identified for supporting roles.

Tracking Progression & Points-of-Contact:

A check-off box for each identified employee allows for easy visual tracking of both the number of steps remaining and the current point-of-contact. While this primarily provided the department heads and primary engineers with the ability to confirm adequate progress, several secondary uses were also identified. Quick comparisons between the number of packages pending action by different engineers within each discipline can identify overloaded or under-utilized personnel, allowing timely redistribution. Additionally, comparison of the number of steps completed and remaining allows for external customers to be easily apprised of the progress and status of their work requests.

5.8 Future Upgrades

At the current stage of development, Phases 1 and 2 or the Smart Base system are in place at NSY Portsmouth. Phases 3 and 4, encompassing the addition of facilities cost data and financial forecasting capabilities, are pending the availability of additional funding through the program. To date, the work order entry and routing tools have proven to be a great success, with strong support from both external customers and internal public works personnel. Regardless of whether the Smart Base program is continued in future fiscal years, the demonstration project at Portsmouth has proven the feasibility and value of building a small-scale, limited-function infrastructure management system.

Chapter 6 Defining an Asset Management Strategy for Winchester, MA

6.1 Background

The town of Winchester, Massachusetts is located northwest of Boston in Middlesex County. Founded in 1630 as an agricultural community, the town was reinvented by the opening of the Middlesex Canal in 1803 and the Boston and Lowell Railroad in 1853. Taking advance of its proximity to the above, the town developed a thriving economy based on textile mills and industrial manufacturing. The town soon grew enough to establish its independence from Woburn and incorporated in 1850. By the late-1800s, the town was again being reinvented into a prosperous suburb of Boston. This trend has continued and today Winchester has become one of the wealthiest towns in Massachusetts.

Comprising only 6.49 square miles, Winchester currently supports a population of just over 20,000 residents.[24] The local government is comprised of a Town Manager and 5 member Board of Selectmen, operating under a Town Meeting form of organization. Each of the 24 precincts elects 8 residents to serve at the Town Meeting, which acts as the sole appropriation authority for the town.

Based on annual revenues, the town of Winchester falls under Phase 2 of the GASB 34 implementation deadlines to report on prospective infrastructure by June 15, 2002. The town will also need to conform with retroactive reporting requirements no later than June 15, 2006. Faced with the need to identify and develop new strategies for complying with GASB 34, the Town Manager and Board of Selectmen approved an information sharing agreement with the Infrastructure Systems Development Research (ISDR) group at the Massachusetts Institute of Technology. This chapter will attempt to summarize the previous actions taken by the ISDR under this agreement.

6.2 Infrastructure Overview

Although relatively small in terms of land mass at under 7 square miles, the town is well developed and maintains a significant portfolio of infrastructure assets. The 90 miles of paved roads are broken down into 18 miles of major roads and 72 miles of minor roads. The sewer system serves the vast majority of all residential areas and includes seven lifting stations used to feed waste to outside treatment plants operated by the Massachusetts Water Resources Authority (MWRA). The building portfolio includes 25 town and school buildings totaling over 800,000 square feet.

The Winchester Department of Public Works (DPW) is in charge of operating and maintaining the roads, sewers, water distribution system, school building, town buildings and public spaces. To aid budgeting, DPW is split into 8 functional areas of operation: Administration, Cemetery, Fields and Public Spaces, Garage, Maintenance of Highways, Maintenance of Buildings, Snow and Ice, Transfer Station, and Water and Sewer. For the purpose of examining infrastructure management practices under GASB 34, the ISDR effort has focused on three of the areas: Maintenance of Highways, Maintenance of Buildings, and Water and Sewer.

Total DPW expenditures have averaged slightly less than 7% of total town expenditures over the past decade. The Water and Sewer area has been operating under an annual budget of approximately $5 million, while the five-year historical average for roads and sidewalks is less than $250,000. It appears this disparity is driven by the fact that water and sewer operations result in the collection of local user fees, while past practice has been to fund road maintenance solely using Chapter 90 funds from the state highway aid fund.

6.3 GIS Database Creation

As an initial step to begin organizing and compiling records in advance of the GASB 34 reporting deadline, Winchester saw the need to implement a database of infrastructure assets. Seeking guidance, the town managers turned to the ISDR group for support of this effort.

6.3.1 Initial Condition

Upon initial inspection by the ISDR team, it became obvious that information technology was not being used effectively within the DPW organization. Existing data sources were discovered to be widely dispersed, incomplete and inconsistently updated. Some basic findings included:

- Limited Computer Aided Drafting (CAD) implementation and a heavy reliance on hand drafted maps and plans dating back to the 1800s.
- No current, complete database of water/sewer/storm lines.
- No program in operation for tracking road and sidewalk condition.
- Very limited, outdated Excel listing of town owned properties containing only location, size and appraised value data.

Lacking even a complete listing of assets contained in the town's infrastructure portfolio, even the most basic of asset management analysis was effectively prevented.

6.3.2 Database Management System Design Goals

As a small town with limited computing and personnel resources, Winchester was concerned about the cost and difficulty of implementing a GASB compliant system. Purchasing commercial asset management software, hiring consultants for ongoing support, and the dedication of a part or full-time database operator were all dismissed as too costly to pursue. As a result, the goal of the ISDR team was to develop a infrastructure database system that was:

- User friendly and usable with a minimum of training
- Simple, providing only the level of detail needed to support GASB 34
- Low-cost

6.3.3 Core Characteristics

In addition to the design criteria above, the ISDR team decide that any software solution had to be highly scalable in size. This was viewed as necessary to deal with the possibility that either the town would find the tools useful and desire addition capabilities or GASB 34 reporting and information requirements would be refined over time. Combined with the requirement to allow multiple user access to avoid the need for a

central data entry position, focus was placed on the adaptation of mass-market commercial software.

To aid ease of use, GIS software was chosen as the front-end to provide a visual reference to the database. ArcView software by ESRI was chosen due to both its reasonable $1500 street price. The back-end database software selected was Microsoft Access, as it was already in use by the town and assured compatible with the disparate Excel databases being kept by the various departments. In order to comply with the fact that GASB defines a "network" as a group of assets where the individual members provide similar services or work together to provide one service[2], the GIS software was configured with separate layers for each type of infrastructure. The 6 layers formed were: roads, drains, water, sewer, buildings and open spaces. In order to maintain simplicity and limit the size of the final database, all layers were tied to segments based on the centerline of complete roads.

6.3.4 Implementation Time

After the system structure was determined, work began on three distinct areas: creating the GIS layers, performing engineering take-offs from existing plans, and searching for historical cost and age data. Work for each task was tracked by the total hours invested. Digitizing paper maps and creating the basic GIS layers required 49 hours. Engineering take-offs for size and length data took 67 hours for the water system, 18.5 hours for sewer and 24 hours for drainage. Collection of historical age and material type data for the sewer system, provided as Appendix A, required 79.5 hours. Assuming similar time is required for age and material research on the water and drainage systems, invested development time would be expected to approach 400 hours.

6.4 Applying Smart Base Concepts

As the town of Winchester continues to develop the existing GIS database tool into an effective asset management system, much can be learned from the concepts and experiences contained in the Smart Base project. Despite significant differences between their infrastructure portfolios, funding issues and information goals, the basic IT strategy

and architecture are flexible enough to serve both groups of users. This chapter will seek to explore the differences, present a set of general methodologies for data analysis, and discuss the specific application issues unique to each town infrastructure system.

6.4.1 Differences Between NSY Portsmouth and Winchester, MA

Before pursuing the application of lessons learned from Smart Base, it is important to understand some of the functional differences between the base and the town. While not an impediment to the application of the overall concepts, they can significantly alter the requirements, priorities and focus of the development efforts.

Types of Infrastructure:

On the surface, a military base is very similar to a small town in both its physical size and self-contained nature. Infrastructure and utility systems such as roads, water and sewer serve as common links between the two. However, the operational nature of military facilities makes for a much more complex and industrial portfolio to manage. Many of the asset classes which are generally seen only in larger cities, such as piers, airfields and power generation plants, are often present at typical military installations. One of the most visible differences between NSY Portsmouth and Winchester is in the quantity and density of public buildings. The shipyard contains a large quantity of individual buildings, allowing building numbers to be an effective primary key for referencing the general location of other infrastructure systems. In comparison, the town is directly responsible for less than a dozen buildings, with the town hall, public works facilities and schools comprising the bulk of the building assets. Therefore the road network in Winchester is better suited for reference purposes and assignment as the primary key, requiring adaptation of the GIS and database methodologies.

Amount of Contact with External Users:

Due to its operational nature and portfolio complexity, the public works department at a naval base experiences much more frequent contact with external customers. High levels of unplanned maintenance and repair requests requires robust processes and procedures to insure efficient receipt, analysis and disposition of trouble calls. A town like

Winchester can be expected to receive only infrequent reports of emergency water, sewer and road problems, allowing a much greater percentage of work to occur as regularly scheduled maintenance. As a result, developing and implementing web-based reporting functions for external customers is of little importance to the town asset management system.

Quantity & Difficulty of Tracked Projects:

Once again, the relative simplicity of the town infrastructure portfolio allows for the development of a simpler asset management strategy. Military bases experience a large backlog of pending work orders, covering a wide range of customers, funding sources and specialized systems. This volume and complexity of work requires a strong tracking and approval system, as demonstrated in the Smart Base case. Under a typical town water, sewer and road portfolio, however, the vast majority of project planning effort is focused within a few well-defined, repetitive categories of common repairs. Similar types of reconstruction work in different areas is commonly bundled into a few larger contracts each year, negating most of the potential benefit of developing automated planning tracking systems.

6.4.2 Elimination & Restructuring of Development Phases

As previously discussed, the Smart Base project at NSY Portsmouth was organized into four development phases:

Phase I	Work Order Requests
Phase II	Internal Approval, Design, Estimating & Funding Routing
Phase III	Facility Condition Data
Phase IV	Financial Forecasting

Table 6.1: Smart Base Development Phases

All four phases provide functions that are commonly included in large, commercial asset management software programs. It must be realized, however, that these functional tools and their relative priority are specific to the perceived needs of that particular application.

Just as the Smart Base phases do not seek to replicate all the features of more complicated asset management systems, small towns seeking GASB 34 compliance should be able to tolerate even less system complexity.

Due to the portfolio differences discussed above, the town of Winchester has little need for the types of functions offered by Phases I and II. The limited amounts of external requests, pending projects, staffing complexity and portfolio variety do not warrant the significant time and resources required to automate these tasks. The primary mission, compliance with the GASB 34 modified approach, is centered around the need to develop, integrate and analyze current cost and condition data. Financial forecasting, while a logical extension of high potential value, is not required by GASB 34 and can be added later as an evolutionary upgrade. As a result, the revised phases of implementation for Winchester can be summarized as:

Phase I	Creation of GIS Interface
Phase II	Research and Entry of Physical Property Data
Phase III	Developing and Interfacing Cost Data
Phase IV	Developing and Interfacing Condition Ratings
Phase V	GASB 34 Calculations & Data Output

Table 6.2: Proposed Winchester, MA Development Phases

Phases I and II have been largely completed and implemented as part of the previous efforts by the ISDR research group. Of significant note, complete and accurate population of physical property databases was complicated by the both the age of the infrastructure assets and the multitude of formats comprising the old hard-copy town records. Appendix A provides a summary of the methodology that was developed to perform physical property data collection on the sewer system. It should be expected that efforts to compile the cost data for Phase III will be impacted by the same asset age and record keeping issues.

6.4.3 Planning Steps

The Smart Base case study demonstrates that strong upfront planning is imperative to the success of any development efforts. In order to create a useful and effective Asset Management System, a government agency must first be able to identify its needs, priorities and capabilities. While it may appear counter-intuitive, small entities often have more difficulty with this than do larger, more complex government agencies. "*The data integration process can be extremely involved and challenging, especially for organizations that have a long history of stand-alone files or rarely share data across database systems.*"[8]

For small towns such as Winchester, which still rely heavily on antiquated hard-copy drawings and files, this can be viewed as both a hindrance and an opportunity. While the lack of existing hardware, software and expertise makes the initial development more time consuming, the long-term benefits of not having to deal with the issues of legacy systems and incompatible file formats results in a much more maintainable system. In addition, there is no pressure to save or replicate existing functions and formats, allowing focus to be placed solely on developing a more simplified system.

In its Data Integration Primer, the U.S. DOT lays out a generic framework of key activities. Although this document was not referenced during the Smart Base project at NSY Portsmouth, closer examination reveals that all the salient points were contained in the progression of their development project. By following the DOT recommendations, combined with the past experiences gained from the Smart Base case study, Winchester can greatly increase is probability of success in developing an effective asset management systems within their time and budget constraints.

Forming a Data Integration Team:

Before proceeding, all the key stakeholders must be brought on-board with the project and adequately represented in the project team. As shown at NSY Portsmouth, inclusion of non-IT personnel at this stage is critical. Personnel impacted by the requirement to populate the system and utilize the data must accept leadership authority over the vision

and direction of the project, while also accepting the guidance and advice of the technical support personnel who must make the system work. Depending upon the sophistication and resources available, towns may need to procure consulting support from firms specializing in asset management systems and data integration.

Like NSY Portsmouth, Winchester has already spent considerable effort creating a strong project team. Support for the GASB compliance efforts are evident at all levels, from the mayor and town council members down through the public works managers who will be ultimately responsible for the system. Similar to the base, where an outside GIS consulting firm was retained, the town has agreed to provide open access in exchange for technical support from the ISDR research group at MIT.

Alternatives Definition, Evaluation & Selection:

At this stage, the key issue is to determine both the type of database architecture and overall scope of the asset management system. Having participated in the specification and development process for the prior GIS database efforts, the Winchester personnel have set a strong tone for the path of further development. The stated goals are built around the development of a simple asset management systems that is inexpensive, maximizes use of existing software, and demands minimal implementation effort. These criteria, while still allowing some measure of flexibility, successfully define the boundaries within which all recommendations and methodologies must be contained.

Development, Testing & Implementation Team:

While the initial testing and debugging is very important, one of the most critical aspects to the long-term success of a new system is the framework put in place to insure its continued updating and support. This is especially true when an interfacing strategy is used to link diverse data sources, as the actions of any one data manager can affect the stability of the entire system. As NSY Portsmouth discovered, it is imperative that regularly scheduled data user meetings be held among the personnel responsible for maintaining the individual portions of the system data. Changes to file locations, names or database fields should only be made after they are discussed and the impact on the

asset management system is reviewed. It has been found that not only do these meetings serve to prevent data compatibility problems, they also serve as a forum for the discussion and testing of continued refinements and improvements. Before embarking on the development of a GASB 34 compliant system, the cognizant Winchester data users need to insure they are committed to establishing and maintaining a regular meeting schedule.

6.5 General System Characteristics

There are significant differences between the goals of the Smart Base project at NSY Portsmouth and Winchester's requirements for GASB 34 compliance. The past GIS work also has a strong bearing on the decisions to be made in developing the asset management system. After reviewing the above, several global system criteria and goals emerge.

6.5.1 Scope of Output

In many ways, the Winchester asset management system can function as a simplified version of the architecture and strategy developed for the Smart Base project. Since there are greatly reduced levels of funding sources and outside customer interactions, these major functional areas do not need to be included in the Winchester system. At its core, the town system can exists as primarily a portfolio tracking tool, focused on the derivation and presentation of infrastructure value and condition data. Planning functions should initially be limited to the creation of output data that can aid the existing manual planning process. The limited number of pending projects and smaller size of the public works staff provides less potential benefit from the difficult task of automating the planning functions. For the same reasons, there is also little benefit to including work tracking or productivity functions.

6.5.2 GIS Software Selection

It is recommended that Winchester continue to use the existing ArcView program to provide the GIS functions for the enhanced system. Although the MapObjects software used by NSY Portsmouth for Smart Base is a more powerful program, its extra

capabilities are immaterial to the needs of the Winchester system. As a small town, it is highly unlikely that the quantity of individual assets being recorded will ever overtax the ArcView program, even considering the possibility that future revisions may include the creation of smaller segment lengths. In addition, the majority of the infrastructure portfolio consists of roads, water lines and sewers that can be adequately represented by line segments and basic physical data, making the additional AutoCAD drawing display capabilities of MapObjects unnecessary. With the limited number of complex buildings and the fact that the majority of public works drawings have not yet been converted to AutoCAD, this part of the design and planning work should remain a manual process.

6.6 Valuation Strategy & Potential Data Sources

As one of the two key pillars required of a GASB 34 compliant system, Phase III requires the development of a strategy for the identification and collection of asset cost data. This data must adequately support the generation of three types of outputs:

- Asset Replacement Costs
- Pending Repair Costs
- Current Depreciated Values

These outputs can be achieved through the creation and interfacing of a separate cost database with the existing physical asset data contained in the ArcView GIS system. However, the town must carefully identify and select the most appropriate cost data sources for each class of assets in the portfolio.

6.6.1 Historical Valuations

Based on its previously published Statement 34 guidance, the GASB appears to prefer assets be capitalized using historical cost data. This method requires the researching of the actual past amounts spent to establish each asset, as well as previous capital improvements. These values then have to be depreciated independently to come up with the current asset value. An "estimated historical cost" method allows for the substitution of representative costs from similar projects in the same timeframe, by making adjustments based on annual changes in the Consumer Price Index (CPI) or Construction Cost Index (CCI). While both of these methods have the advantage of being based on the

actual amounts spent on each infrastructure asset, they also have significant drawbacks that hinder their use.

For many older New England towns such as Winchester, a significant portion of the underground utilities were installed between the late-1800s and the post-WWII era. Town records do not contain contractual and accounting files this old, making it impossible to research the actual costs incurred at the time of construction. Even the estimated cost model can not be effectively applied, as magnitude of shifts in the CPI and CCI between different decades would cause an unacceptably high level of error. In addition, the assets are so old that even the longest of depreciation schedules would value them as completely written off, causing the majority of the infrastructure to be represented only as the depreciated cost of recent repairs and thereby vastly underestimating the value of the portfolio.

6.6.2 Proposed Adjusted Current Replacement Cost Strategy

The proposed valuation method is developed by combining two concepts allowed by the GASB. In the event that reporting entities have difficulty securing historical cost data, the use of "deflated current replacement costs" is allowed.[8] Under this method, the town would combine current cost data with the physical characteristic database, then adjust the value back to the cost in the year of construction using the CPI and CCI indexes. While this has many of the same accuracy drawbacks as the "estimated historical cost" method, the ability to find reliable current cost data is preferable to interpolating between a limited number of historical data points. Therefore, the use of a modified form of the current replacement cost method is proposed for the Winchester valuation strategy.

The use of the replacement cost data does not automatically solve the depreciation issues caused by the age of the infrastructure portfolio. This is corrected by the application of the second valuation concept. As long as the asset management and performance requirements of the GASB 34 modified approach are met, government entities will not be required to depreciate covered assets. As a result, even older assets that are still in use and kept in acceptable states of repair can have their full current values represented in the

portfolio valuation. Since depreciation will not be used to account for wear, an alternate method must be found for adjusting the replacement cost to reflect the true current value. The recommended method is:

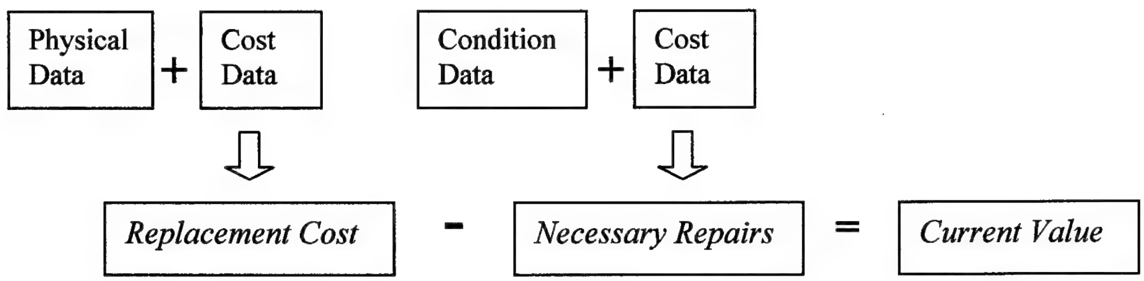


Figure 6.1: Valuation Calculation Strategy

Assuming that the completion of identified repair and reconstruction efforts are intended to return infrastructure assets to original levels of usability, and therefore original levels of value, this method should produce an accurate representation of current portfolio values. In addition, the interim calculations and data analysis required to support the method provide critical inputs to other aspects of the asset management system. Being able to quickly analyze replacement values and necessary repairs by streets, neighborhoods and complete systems provides incredible levels of information for both performance review and future planning efforts. Comparison of constructions and maintenance spending levels against assets replacements costs can provide insight into whether adequate levels of O&M spending are being allocated to different systems, neighborhoods and the overall portfolio. Tracking pending repair costs can be used to aid current year allocation efforts by identifying which areas and systems have the greatest needs, as well as provide easy year to year comparisons of whether repair backlogs are increasing or decreasing. Finally, as will be discussed in the next section, these calculations can also form the core of a simple, effective condition rating system.

6.6.3 Potential Data Sources

For the proposed valuation method to work, accurate sources of replacement and repair data need to be identified. While estimating is often referred to as more of an art form than a science, relying highly on subjective decisions and experiences, this application

demands the use of more objective criteria than might otherwise be required. The inclusion of the derived information in certified financial statements requires the existence of a logical methodology that can be clearly explained and supported. The ability to make accurate year to year comparisons of the financial and condition results is directly dependent of the repeatability and consistency of the underlying data analysis. Relying on the subjective interpretations of a limited number of town estimating personnel would not only decrease the accuracy of the asset management information, it would also create major transitional problems as key personnel retired or were replaced. As a result, potential sources of objective cost data have been researched, and the following three identified as most applicable to the town of Winchester.

Current Town Contracts:

The best source of current year construction and repair cost data would be actual contracts currently in effect by the town. Using this source would have two primary advantages. First, the cost data would be from the current fiscal year, and would not require additional adjustment steps using the CPI and CCI. Second, the cost data would represent the going rates for work by locally available contractors in the exact geographic area of concern. Both of these factors conspire to greatly increase the accuracy and applicability or the compiled data, making this the preferred source.

In order to increase the future effectiveness and quantity or cost data available under this method, there are several steps the town of Winchester should take to adjust their contracting strategy. First, an increased emphasis should be placed on issuing unit price contracts whenever possible. This would provide direct cost data for individual line items of work, eliminating the error involved in trying to derive these prices by breaking down a more comprehensive contract total. For example, a repaving contract with different unit prices for linear foot repaving of 16' roads, 20' roads and sidewalks provides a much greater level of information than the issuance of a lump-sum contract.

Once the town is comfortable with the issuance of unit price contracts, the next logical step can be taken. For many years, large infrastructure managers such as the Navy have

relied on the issuance of indefinite-delivery, indefinite-quantity (IDIQ) contracts. Each fiscal year, different types of work are competitively bid on a line-item basis. Contracts are then awarded to one or more contractors, making them the preferred vendors of the selected services. Since the unit prices are set in advance, the customer only has to issue task orders specifying the quantity of each line item to be performed. For common, repetitive types of work such as road repaving, water line repairs, or pothole maintenance, these IDIQ contracts can provide a great benefit to the towns. Emergency repair work can be obtained without the need to perform competitive bidding, contractors will tend to offer lower prices with the knowledge that they should receive a greater volume of work, and unexpected last minute funds can be quickly allocated and committed. Most importantly, cost data fed into the GASB asset management system would represent the actual current costs of repairs, rather than simply an estimate.

Recent Historical Data:

The use of recent historical data from local contracts can also serve as a good source of reliable infrastructure cost data. While the use of prior year contract data does require minimal adjustments using either the CPI or CCI, all of the other benefits and recommendations still apply. In addition, the potential exists for sharing information with neighboring towns. This can serve to provide data for work that Winchester may not have contracted for in the recent past, while still providing real-world costs representative of local contractors and market conditions. However, as discussed previously, the extent to which unit-cost contracts have been used in the past will greatly impact the quantity and accuracy of the historical data available.

Commercial Estimating Guides:

As an alternate method, Winchester should select one of the commercially available estimating guides. Published annually, there are several competing regional and national guides available. While not specific to the town, these sources are compiled by averaging an extremely large amount of current data from a diverse range of users. Comparative cost indexes are provided to facilitate the adjustment of the raw data to different regions, states and metropolitan areas.

Again, because of the public disclosure aspect of the GASB 34 reports and supporting statements, it is important that Winchester select a well known, highly regarded source. For the purpose of this discussion, it will be assumed that publications produced by RS Means will be adopted and used. Selecting this series of products has several advantages. First, the RS Means guides are widely used is other government agencies, including the contracting divisions of the Department of Defense. Second, the data is available as either set of conventional printed manuals or the CostWorks software on CD Rom. Third, the data is logically organized in multiple levels of detail, from very detailed line item costs to extremely broad square footage cost ranges for different facility types. The grouping of common line items into assemblies for common projects, such as the repaving of roads in different widths and pavement thicknesses, provides a source of extremely useful all-inclusive costs which can greatly simplify the challenges of inputting and interfacing between the databases. Finally, the inclusion of regional and annual adjustment indexes in both the printed guides and CD Rom eliminate the need to seek and incorporate an additional outside source of this info.

6.7 Condition Rating Methodology

As the second pillar of a GASB 34 compliant asset management system, Phase IV requires the development and implementation of a rating system to assess the condition of the town infrastructure portfolio. Meeting this rating requirement consists of two distinct steps. First, criteria must be identified to provide guidelines for the consistent annual inspection of all assets and systems, with the goal of minimizing the impact of the subjective nature of this task. Second, a method must be developed to convert these detailed condition assessments into an simple, objective rating system that can be clearly presented in the annual GASB 34 reports.

6.7.1 Existing Manual & Software Based Rating Systems

The first step in populating a condition assessment database is the performance of on-site inspection surveys of each infrastructure system. While this has normally been accomplished in the past as part of normal public works operations and planning, it

generally has been more of a spot-check process with only infrequent system-wide inspections. In order to better support the levels of documentation and accountability sought by the GASB standards, it is critical that future assessments be made using a standardized process on an annual basis. While any inspection process will have to continue to rely on subjective assessments by different personnel, implementing a structured process with well defined criteria and reporting forms can minimize unwanted rating variations.

For this part of the project, there is no need for Winchester to try and reinvent the wheel. A wide variety of governmental agencies have already developed and refined rating criteria for a range of different assets. It is therefore only a matter of reviewing several of the existing systems for each asset class, then selecting the one which the individual public works departments are most comfortable. With respect to roads, for example, Winchester already relies on condition studies completed by the Metropolitan Area Planning Council (MAPC) to maintain a stand-alone FoxPro database of physical criteria and surface condition. While last performed in 1997 by the MAPC, utilizing the inspection forms shown in Appendix B for yearly updates by town personnel should save significant development effort, while also providing the GASB with the knowledge that a widely respected inspection system is being used. Alternately, a computer based assessment and forecasting tool, such as the RSMS00 Road Surface Management System from the University of New Hampshire Technology Transfer Center, could be used.

For other infrastructure types where no outside inspection system is currently in use by the town, the various branches of the Department of Defense provide a valuable resource for the adaption and incorporation of inspection guidelines. An excellent example is the NAVFAC MO-322, published by the U.S. Navy to assist in the completion of annual AIS and BEMS inspections. "This manual contains policy and criteria for the inspection and condition assessment of shore facilities and preventive maintenance of equipment. It provides guidance to implement and maintain and inspection / assessment program."[23] Reviewing and adapting these types of procedures and inspection forms to match the internal preferences of the public works personnel can provide a significant time and cost

savings to Winchester. Separate condition databases, similar to the FoxPro one already in place for MAPC road data, can then be created and interfaced with the GIS system.

6.7.2 Financial Based Numeric Condition Rating Methodology

Along with the details of the condition assessment databases, there is the need for a methodology to convert the subjective ratings into an objective scoring system. Ideally, condition scores should be available for individual infrastructure assets, systems, and the portfolio as a whole. The Navy procedures offer only limited guidance in this area, as their main focus is on providing big-picture operational impact assessments reported on a scale from C-1 to C-4. However, one aspect of the base planning and budgeting system provides a useful starting point. When initially deciding whether to pursue major maintenance, rehabilitation or complete replacement of an individual facility, analysis is performed by comparing the total of necessary repairs to the replacement cost of the infrastructure. If repairs are predicted to exceed a pre-determined percentage of the replacement cost, the project is transferred to the new construction request process.

For GASB 34 reporting purposes, the recommendation is to adapt this strategy to create a range of ranking zones. The cost data necessary to support this, which includes both replacement and repair costs for all individual assets, will already be available from the valuation strategy discussed in Section 9.3. To provide condition analysis, the data simply needs to be combined in an alternate way. Repair costs can be divided into the replacement cost to provide a Repair Ratio. Different ranges of ratios can then be assigned either a numeric or descriptive title. While the individual performance measures may vary by system, with more critical assets such as water and sewer being held to higher standards, a sample rating conversion would be structured similar to:

Repair Ratio Range	Score	Rating
< 10%	1	Excellent
11 – 25%	2	Good
26 – 50%	3	Fair
> 50%	4	Poor

Table 6.3: Sample Rating Assignment Chart

6.7.3 Sample Flow-path for Condition Rating

A summary of the data interactions required to is visually represented below:

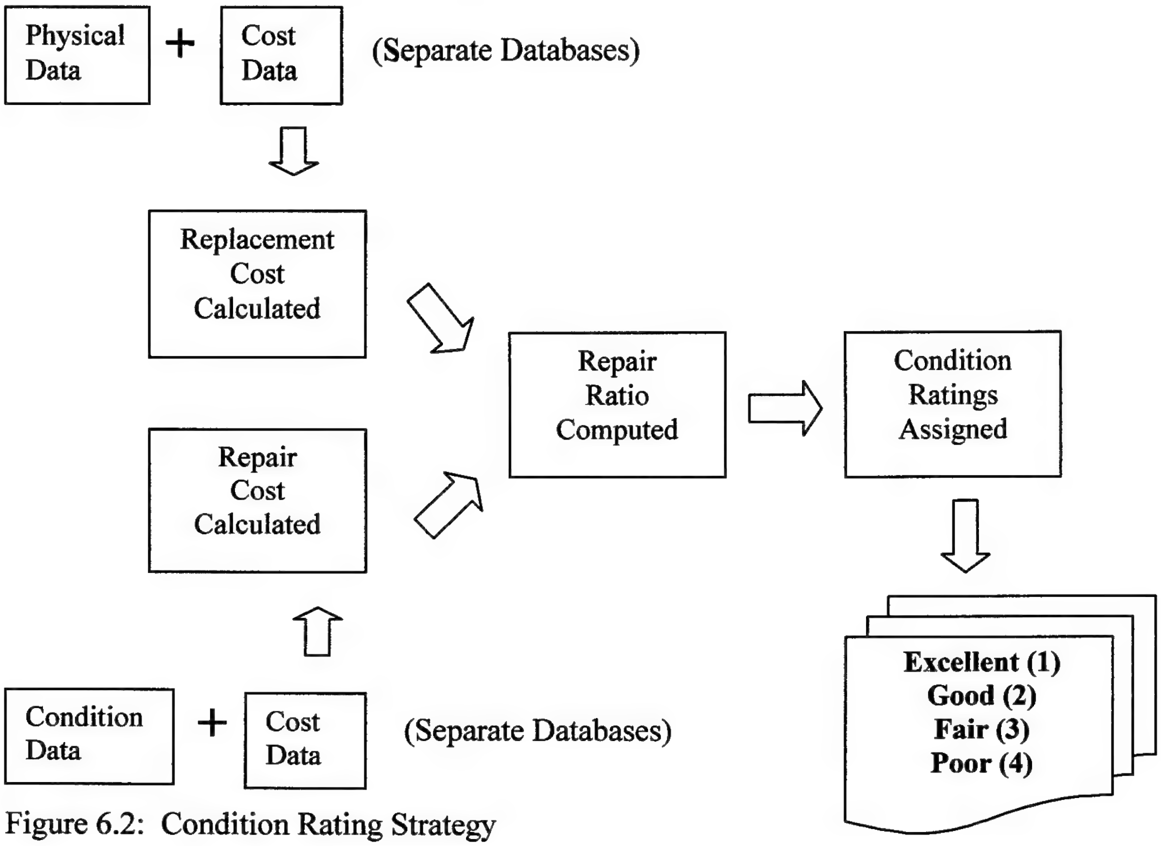


Figure 6.2: Condition Rating Strategy

6.8 Issues Within Groups of Infrastructure Type

While the above methodology should allow for the successful implementation of an asset management system for all the infrastructure systems contained in the Winchester portfolio, there are unique characteristics of each that need to be incorporated. At present, the following infrastructure assets are expected to be tracked under the GASB 34 Modified Approach: roads, water lines, sewer lines, and public buildings. For each of these systems, implementation decisions need to be made in the following four areas:

- Types of Data Required
- Data Sources for Physical Characteristics
- Applicable Cost & Value Information Sources
- Potential Inspection & Ratings Systems

6.8.1 Road Network

As the largest single component of the Winchester portfolio, as well as the most visible and subject to wear, improving management of the road network is a top priority. To the towns benefit, this is also the system with the greatest variety of data sources and outside inspection tools.

The types of data have been well defined and selected under the prior GIS work. Physical characteristics documented include road width, pavement thickness, and presence of absences of curbs. Since actual road construction data is not available for the vast majority of the towns roads, it is reasonable to assume that all roads meet the current public works standards for new road construction, as this would represent the scope of work required to produce actual replacement costs. Regardless of variations in past overlay thickness, all replacement and repaving costs will be calculated based on roads of standard widths and pavement thickness. Useful but not mandatory would be data on the dates of the most recent repaving and major reconstruction work, which could provide a useful double-check to the condition inspections. Currently, the best source for physical dimension data appears to be the MAPC Fox Pro database, which has already been incorporated into the ArcView GIS system. The MAPC inspection guidelines and forms, already in use by over 100 Massachusetts cities and towns, should be adopted for the annual condition surveys required by GASB.

The road system, more than any other, holds the potential for extremely accurate and timely valuation information. Road repaving and reconstruction is a large part of the annual public works budget, provide a significant volume of historical cost data. Initially, use of RS Means data should be pursued, as this is already adapted to the unit cost estimating environment recommended above. As Winchester officials begin to break historical contract costs into local unit price estimates and issue line-item contracts tied to the GIS data, this local data source can replace the RS Means data.

6.8.2 Water Distribution System

Due to the recent completion of a major, multi-year relining project, the Winchester water distribution system has the next most reliable source of physical and condition data. Interfacing directly with the stand-alone database used in support of this relining work should provide the most reliable information on pipe size, location and material, and has already been incorporated into the ArcView GIS system.

For the water system, condition assessment becomes a much greater problem than with the road network. Conditions of underground systems are notoriously hard to gauge, with the exception of feedback from limited spot inspections and occasional emergency repairs. For the purpose of GASB reporting, it can safely be assumed that the cleaned, relined pipes are fully operational and can be functionally treated as if they were new, unlined pipes. The difficulty will be in determining when to downgrade condition ratings as the system continues to age. Public works managers will need to create a procedure to track the location and number of unplanned breaks and repairs, downgrading condition ratings once certain frequency and severity thresholds are met.

Valuation of the water system also poses a bit of a dilemma, as the actual buried depth of any particular line can vary significantly over it length. This impacts the excavation and backfill costs that comprise a portion of both the replacement and repair cost estimates. The only feasible solution is for the public works personnel to select an average water line depth based on their past experiences, and accept the fact that any valuations provided will contain a small degree of error.

6.8.3 Sewer System

Rating and valuing the sewer system faces the same issues as the water distribution system, but to a greater degree. The Winchester system has not been lined, so the physical condition of the pipes is much more uncertain. Limited inspections have been performed as a part of infiltration and inflow studies, but condition information is primarily limited to selected manholes and short sections of pipe. Although a major robotic inspection project is beginning this year, only a small portion of the system will

be studied each year. As a result, sewer condition ratings will have to rely primarily on more subjective assessments supported by the collection of emergency repair data.

Calculation of repair and replacement costs will also prove to be more difficult for the sewer system. As presented in Appendix A, the age of the sewer system resulted in difficulty determining the pipe material data for a high percentage of the lines. Similar to the road strategy above, the best solution is to perform the calculations based solely on the replacement materials that are currently in use for new installations, regardless of the possible material types previously installed. A greater challenge is that the Winchester sewer is primarily a gravity fed system, resulting in much greater variations in buried depth. Selection of an average depth for calculations will have to again be used, but will cause a much greater degree of estimating error than in the case of the water system.

6.8.4 Public Buildings

Due to their small role in the overall portfolio, valuation of the limited number of public buildings should be done as simply as possible. For replacement cost data, two options exist. Town property assessments, if available, provide the advantage of placing a value on both the structures and the land. In comparison, the use of RS Means square foot costs for different types of structures can provide a very general range of replacement values for the buildings alone. Comparisons of the town assessments and both the low and high range of RS Means values will need to be compared, with the ultimate valuations being a subjective combination of these two data sources.

Also, because of the complexity and variation of repairs required for buildings, it is recommended that the repair tracking and estimating continue to be performed manually. Attempts to automate and integrate the individual repair and estimating data would needlessly complicate the development efforts and provide little or no real benefit. Instead, all outstanding work requests at the end of the fiscal year should be totaled and then fed into the GIS asset management system as a single overall value.

Chapter 7 Recommendations & Conclusions

7.1 Recommended Future System Upgrades

The initial GIS database designed in support of GASB 34 compliance efforts in Winchester, MA was developed with the goal of being as simple and user friendly as possible. While this made the system easier to initially design, test and build user, the resultant architecture limitations have a significant long-term impact. The use of a single layer GIS map and full-length road segments allowed a reduction in the quantity of managed data, but also resulted in losses in system flexibility and available level of detail. The proposed methodologies for implementing the additional asset management functions were designed to fully meet all the GASB 34 modified approach requirements, without requiring any changes to the underlying GIS database structure. However, after the value of the initial system is proven and if more development funds are allocated by the town, it is recommended that future upgrades be considered in the following areas.

7.1.1 Global System Upgrades

There are several simple upgrades that can greatly increase the quantity and quality of infrastructure information contained within the asset management system. While both will increase the data storage demands and slightly increase overall complexity, the advantages should easily outweigh the negatives.

GIS Layers:

In order to reduce complexity for the end users, the GIS database system was built around a single ArcView layer. This was made possible through the use of road names as the "primary key" to identify segments of all utility systems in the database. Although several water and sewer lines that did not run along the existing road system needed to be renamed and identified under non-existent road extensions, the level of these exceptions was very minor. However, this architecture has two primary problems. First, it disregards the fact that different infrastructure systems may be better represented as alternately sized segments. Second, it makes it more difficult for the users to graphically

isolate and examine the systems individually. Future upgrade efforts should seriously consider the possibility of assigning a separate GIS layer to each town infrastructure system.

Contract Data:

As previously discussed, current contract data from either Winchester or the surrounding towns is preferable to using commercial estimating guides. While the use of RS Means data is still recommended to aid in initial development and valuation calculations, efforts should be made to continually increase reliance on actual data from local contracts. This could be supported by the issuance of more unit price contracts, with the ultimate goal being to implement standing IDIQ contracts for a wide range of common repairs.

7.1.2 Road Upgrades

The greatest current limitation on the road system data, with the exception of only the longest four roads, is that the segment lengths are set to be the full length of the each street. This creates two difficulties. First, the large variation in lengths makes direct comparison difficult, especially when examining lists of necessary repairs. Second, this method does not correspond to the setup already in use by the available road inspection forms and software packages. It is recommended that future upgrade efforts include a switch to using series of standard length segments to represent each street.

7.1.3 Water / Sewer Upgrades

The linking of each water and sewer line to the length of the associated streets is a cause for even greater concern. In addition to the drawbacks listed above, there is also a problem with pipe sizes and materials changing multiple times along each segment. Currently, the database works around this by reporting the approximate percentage each of the three largest sizes makes up in each segment. While this allows overall system valuations to be computed, it creates a higher level of inaccuracy than is ultimately desirable. Switching to either manhole-to-manhole segments or standard length segments would greatly increase the level of detail and information available to the users.

7.1.4 Building Upgrades

The use of general square footage analysis and RS Means data should continue to prove adequate for generating the required output data, especially considering the small role of Winchester's public buildings in the overall portfolio. As low priority items, several possible upgrades could be made. First, the database for each building could be expanded to include information of the major systems and equipment in each building. This could include info such as brands, model numbers, repair points of contact, and warrantees. Second, switch to CAD floorplan drawings and the replacement of the ArcView software with Map Objects software could greatly improve the value as a planning tool, but is a long-term, high-cost option that is unnecessary for primary goal of achieving GASB 34 compliance.

7.2 Conclusions

As theorized, the implementation and adaptation of existing U.S. Navy asset management experience and practices can minimize both the expense and difficulty to local governments of complying with the GASB 34 modified approach. Adopting a strategy of interfacing existing GIS databases, combined with simple analysis methodologies and carefully selected data sources, can eliminate the need to purchase expensive commercial asset management software systems. In summary, some of the most important lessons discovered during the course of this research are:

- The GASB 34 Modified Approach, while requiring more effort to implement, is vastly more valuable to future infrastructure management.
- The application of lessons learned from the Navy Smart Base initiative provides a cost-effective framework for towns and cities seeking to develop small-scale asset management systems.
- Winchester, MA can readily adapt their existing ArcView GIS database to become compliant with the GASB 34 modified approach with a minimum investment of time and effort.
- RS Means is the best primary source of cost data for small towns without a large volume of historical contract data.

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Appendix A Winchester Sewer Data Collection

Background

Government Accounting Standards Board (GASB) Statement 34 requires that local governments generate infrastructure asset management and condition evaluation databases. As demonstrated by previous research performed by the infrastructure development group at MIT, government organizations have often neglected to track and aggregate data on local infrastructure in a cohesive manner. To aid in the compliance with GASB 34, a system needs to be developed to aid these governments in the collection and analysis of system data. While data can be collected through either the review of historical documentation or physical inspection of the systems, reliance on existing documents should be relied on as the primary collection method to minimize expenditure of time and labor. In February 2002, the following information review process was utilized in an attempt to document the Winchester, MA sewer system.

Data Required

In order to comply with the GASB 34 reporting requirements, the research team was tasked with finding the following types of data for each pipe run in the sewer system: pipe size, pipe age, pipe material, and historical costs. An existing database, previously created through performing engineering take-offs from town maps, contained approximately 400 sewer segments requiring data entry. The take-off process had successfully provided pipe size information for nearly all the sewer segments, but had been unable to provide age, material and cost data.

Data Source Identification

In order to collect the missing sewer system data, arrangements were made to gain access to the engineering archives located at the Winchester town office. Interviews with town employees confirmed that no existing files, databases or drawings contained all the desired data in one location; requiring the eventual use and of separate data sources. A

physical search of the engineering vault identified the following four potential data sources:

1. Sewer Assessment Maps
2. 1980 Sewer System Evaluation Study
3. 1978 Winchester Infiltration / Inflow Study
4. Sewer House Connection Card File

Initial spot checks of each source resulted in the following observations. Source 1 was organized as 232 maps numbered from 2401 to 2633, which appeared to landscape and profile views for a single pipe runs on individual streets, including size and install date information. Sources 2 and 3 contained details of manhole inspections for portions of the sewer system, including pipe size and material information. Source 4 provided dated connection information, organized by street name.

Initial Assumptions & Decisions

After the initial identification and review of the data sources above, it was decided that the following review guidelines would be implemented:

1. One person should be designated with the sole function of updating the database on a portable computer immediately as data was identified.
2. The other one or two people should both examine the data sources and maintain a paper log of all data identified from each.
3. Data previously identified through the engineering take-offs should be spot checked against new duplicate data to subjectively examine the accuracy of the take-off process.
4. The Sewer Assessment Maps would be utilized first, based on the assumption that they would be the most comprehensive source and contain several types of data.
5. The two sewer studies were to be examined next, as they appeared ot contain several types of data.
6. If not installation date information could be determined from the Sewer Assessment maps, the date of the earliest house connection would be used.
7. In the event of data conflicts, the newer data source would prevail.

Based on the pre-existing structure of the asset management database to be populated with data, the following limitations were imposed on the process:

1. Only the three largest pipe sizes were documented for each segment.
2. Only one installation date data block existed for each segment.
3. Only one material type data block existed for each segment.

Data Collection

Sewer Assessment Maps

As discussed above, the town sewer assessment map were the first data source that was analyzed. This data source provided 128 new data points, comprised of 98 initial install years and 30 material types. Total time effort spent on this data source was 56.5 man-hours. The following issues and decisions were encountered while using these maps.

Issues:

- Different parts of each sewer segment, which were principally linked to entire street lengths in the previously developed database, were often installed in very different years as the town expanded.
- Pipe material data was only listed for certain install years on multi-year segments.

Solutions / Decisions:

- Only the oldest install year that comprised greater than 30% of the total segment length was enter in the one available data block.
- If pipe material was known for any portion of a database segment, it was listed in the one available data block.

1980 Sewer System Evaluation Study

The second data source analyzed was the sewer system evaluation study that was completed in 1980. This data source provided 27 new data points, comprised of 24 material types and 3 pipe sizes. Total time effort spent on this data source was 3 man-hours. The following issues and decisions were encountered while using this source.

Issues:

- Material data was only provide for isolated manholes contained in multi manhole segments.

Solutions / Decisions:

- If pipe material was known for any point in a database segment, it was listed in the one available data block.

1978 Winchester Infiltration / Inflow Study

The third data source analyzed was the infiltration / inflow study completed in 1978. This data source provided 31 new data points, comprised of 30 material types and 1 pipe size. Total time effort spent on this data source was 3 man-hours. No new data collection issues were raised during the use of this source.

Issues:

- Different parts of each sewer segment, which were principally linked to entire street lengths in the previously developed database, were often installed in very different years as the town expanded.
- Pipe material data was only listed for certain install years on multi-year segments.

Solutions / Decisions:

- Only the oldest install year that comprised greater than 30% of the total segment length was enter in the one available data block.
- If pipe material was known for any portion of a database segment, it was listed in the one available data block.

Sewer House Connection Card File

The final data source analyzed was the sewer connection card file. This data source provided 166 new data points, comprised of 154 connection years, 10 material types and 2 pipe sizes. Total time effort spent on this data source was 27 man-hours. The following issues and decisions were encountered this source.

Issues:

- Earliest connection year is not necessarily the year the pipe was installed in the street.
- Some cards listed multiple material types for different portions along a database segment.
- Year, material and size data now for some database segments now came from multiple sources.

Solutions / Decisions:

- The earliest connection was to be used as the install year entered, based on the assumption that initial connections would have been made immediately following the availability of sewer service.
- A coding system was developed to identify different material types in the data block: 1 for Vitreous Clay (VC), 2 for Asbestos Cement (AC), 3 for a combination of VC and AC, and 4 for PVC.
- An additional data block was added for each segment and a coding system developed to identify the data source: 1 for the Sewer Assessment Maps, 2 for the 1980 Sewer Assessment Survey, 3 for multiple sources, 4 for the 1978 Infiltration / Inflow Survey and 5 for the Sewer House Connection Cards.

Summary of Data Collection

The four data sources examined provided a range of data type, quantity and effort required, as summarized in the table below:

Source	Years	Materials	Sizes	Total Data	Man-Hours
Sewer Assessment Maps	98	30	0	128	46.5
Sewer System Eval Survey	0	24	3	27	3
Infiltration / Inflow Study	0	30	1	31	3
House Connection Cards	154	10	2	166	27

Appendix B MAPC Pavement Management Data & Inspection Forms

MAPC

MEMORANDUM

TO: Municipal Officials

FROM: Jim Fitzgerald
Transportation Planner

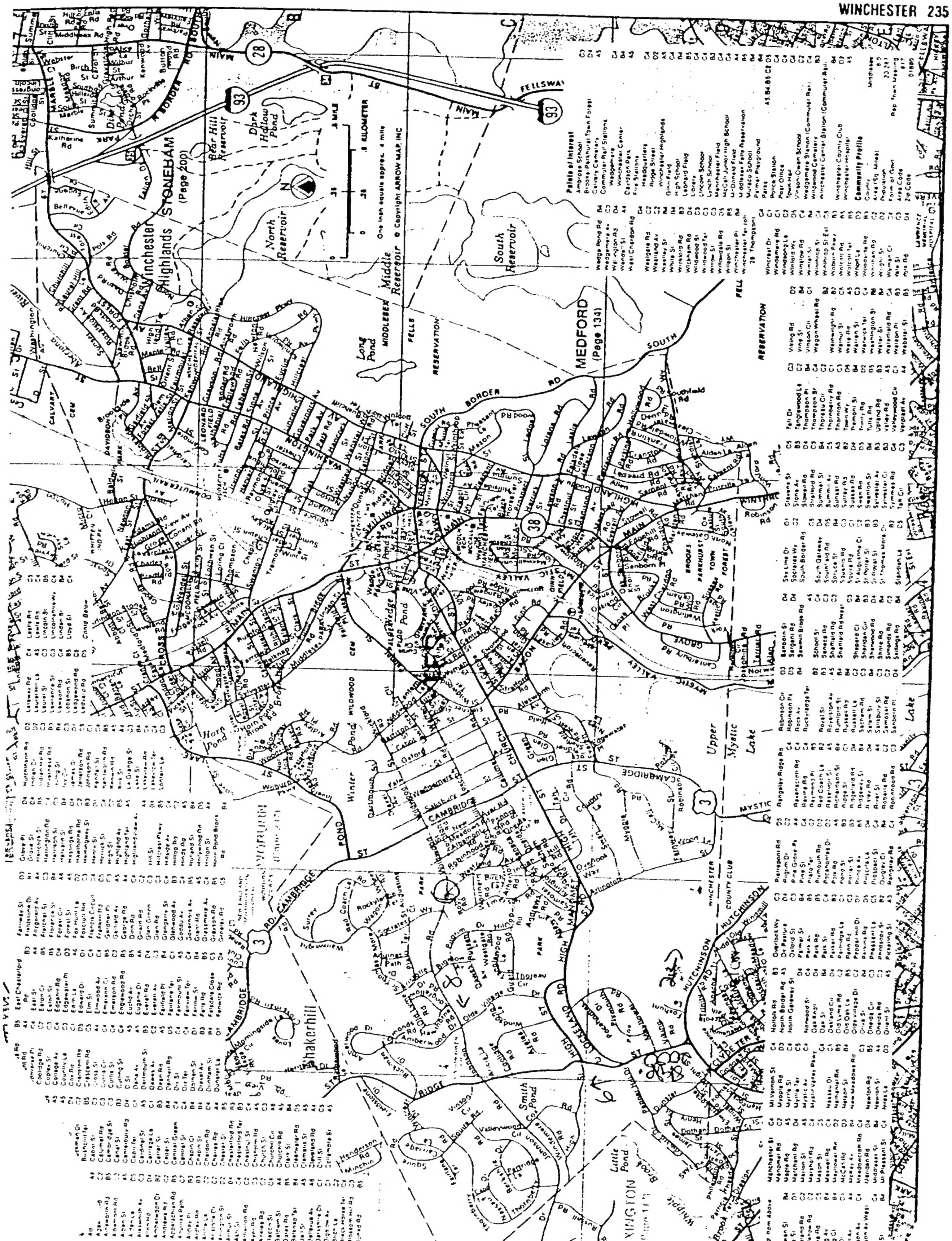
DATE: February 6, 2002

RE: Requested 1997 Pavement Management Data

As requested, enclosed please find the Pavement Management Roadway Inspection Forms generated for your municipality, as part of MAPC's 1997 data collection efforts on this project.

Please let me know if you have additional questions.

60 Temple Place ■ Boston, MA ■ (617) 451-2770 ■ Fax (617) 482-7185


STONEHAM (Page 200)
MEDFORD (Page 134)
Winchester Highlands
North Reservoir
South Reservoir
Middle Reservoir
Upper Mystic Lake
Horn Pond
Wedge Pond
Shakerhill
Little Pond
Long Pond
Bear Hill Reservoir
Dark Hollow Pond
Smith Pond
FELLS RESERVATION
MIDDLESEX
Copyright ARROW MAP INC

MAPC Pavement Management — Roadway Inspection Form

Please fill out this form for each **inspection unit sample** surveyed in the road network. NORTH SUBURBAN

Municipality / District WINCHESTER City/Town# 344

Street Name 344 Grove St. Serial #

Street ID 0126 Section 300 Length (ft) 950.4

Begin Location of Section 0092 Bacon St. Width: 28

End Location of Section M176 Medford Funding: STP

Survey Date: 6/12 Rater's Initials: SS Inspection Unit # 1 of 1

Inspection Unit Start Location Medford

Inspection Unit End Location 100' N

Sample Width (ft) 28 Sample Length (ft) 100

Sample Area (sq. ft) 2800

Distress	Severity Level: Low	Medium	High	Extent (% Area): 0-1	>1-5	>5-10	10+
1. Patches & Potholes	☐	☐	☐	☐	☐	☐	☐
2. Alligator Cracking	☐	☐	☐	☐	☐	☐	☐
3. Distortions	☐	☐	☐	☐	☐	☐	☐

Distress	Low	Medium	High	0-5	>5-50	>50-75	75+
4. Rutting	☐	☐	☐	☐	☐	☐	☐
5. Weathering/Block Cracking	☐	☐	☐	☐	☐	☐	☐
6. Transverse/Longitudinal Cracking	☒	☐	☐	☒	☐	☐	☐

Distress	Low	High	Localized	Extensive
7. Bleeding/Polished Aggregate	☐	☐	☐	☐
8. Surface Wear and Raveling	☒	☐	☒	☐
9. Corrugations, Shoving & Slippage	☐	☐	☐	☐

Curb Reveal:

Comments:

data\My Documents/Pavement-General/References & Templates/Blank Inspection Form.doc Update 5/96

STP Roads

Street ID	Street Name	Section	Section Beginning	Section End	Func. Class	Pave. Type	Width (ft)	Length (ft)
0057	344 ARLINGTON STREET	100	0023 WESTLAND AVENUE	0001 CAMBRIDGE STREET	2	2	30.0	1,425.6
0092	344 BACON STREET	100	0003 CHURCH STREET	0107 MAIN STREET	2	2	30.0	1,161.6
0092	344 BACON STREET	200	0003 CHURCH STREET	0107 MAIN STREET	2	2	30.0	1,003.2
0092	344 BACON STREET	300	0003 CHURCH STREET	0107 MAIN STREET	1	2	30.0	897.6
0092	344 BACON STREET	400	0003 CHURCH STREET	0107 MAIN STREET	1	2	30.0	1,003.2
0066	344 BLOSSOM HILL ROA	100	0001 CAMBRIDGE STREET	0023 WESTLAND AVENUE	2	2	26.0	1,267.2
0127	344 CHESTERFORD ROAD	100	0065 POND STREET	0012 WOODSIDE ROAD	2	2	24.0	1,056.0
0003	344 CHURCH STREET	100	0107 MAIN STREET	0001 CAMBRIDGE STREET	1	2	36.0	1,795.2
0003	344 CHURCH STREET	200	0107 MAIN STREET	0001 CAMBRIDGE STREET	1	2	44.0	739.2
0003	344 CHURCH STREET	300	0107 MAIN STREET	0001 CAMBRIDGE STREET	1	2	44.0	792.0
0003	344 CHURCH STREET	400	0107 MAIN STREET	0001 CAMBRIDGE STREET	1	2	44.0	1,795.2
0173	344 CLEVELAND ROAD	100	0164 CROSS STREET	W347 Woburn	2	1	25.0	475.2
0164	344 CROSS STREET	100	0163 WASHINGTON STREET	W347 Woburn	2	2	30.0	792.0
0164	344 CROSS STREET	200	0163 WASHINGTON STREET	W347 Woburn	2	2	30.0	1,320.0
0164	344 CROSS STREET	300	0163 WASHINGTON STREET	W347 Woburn	2	2	30.0	1,795.2
0164	344 CROSS STREET	400	0163 WASHINGTON STREET	W347 Woburn	2	2	30.0	1,636.8
0169	344 EAST STREET	100	0168 HOLTON STREET	W347 Woburn	2	1	22.0	1,320.0
0007	344 FLETCHER STREET	100	0003 CHURCH STREET	0002 WILDWOOD STREET	2	2	30.0	1,161.6
0166	344 FOREST STREET	100	S284 Stoneham	0164 CROSS STREET	1	2	42.0	264.0
0166	344 FOREST STREET	200	S284 Stoneham	0164 CROSS STREET	1	2	42.0	686.4
0166	344 FOREST STREET	300	S284 Stoneham	0164 CROSS STREET	1	2	32.0	2,745.6
0166	344 FOREST STREET	400	S284 Stoneham	0164 CROSS STREET	1	2	32.0	1,372.8
0126	344 GROVE STREET	100	0092 BACON STREET	M176 Medford	2	2	28.0	1,795.2
0126	344 GROVE STREET	200	0092 BACON STREET	M176 Medford	2	2	28.0	897.6
0126	344 GROVE STREET	300	0092 BACON STREET	M176 Medford	2	2	28.0	950.4
0040	344 HIGH STREET	100	0001 CAMBRIDGE STREET	0000 DEAD END	1	2	31.0	1,320.0
0040	344 HIGH STREET	200	0001 CAMBRIDGE STREET	0000 DEAD END	1	2	31.0	950.4
0040	344 HIGH STREET	300	0001 CAMBRIDGE STREET	0000 DEAD END	1	2	31.0	475.2
0040	344 HIGH STREET	400	0001 CAMBRIDGE STREET	0000 DEAD END	1	2	17.0	686.4
0040	344 HIGH STREET	500	0001 CAMBRIDGE STREET	0000 DEAD END	1	2	28.0	686.4
0216	344 HIGHLAND AVENUE	100	0166 FOREST STREET	0107 MAIN STREET	1	2	31.0	897.6
0216	344 HIGHLAND AVENUE	200	0166 FOREST STREET	0107 MAIN STREET	1	2	31.0	2,112.0

Functional Class: 1-arterial, 2-collector, 3-local
Pavement Type: 1-Surface Treatment, 2-Bituminous Concrete, 3-Composite, 4-Gravel